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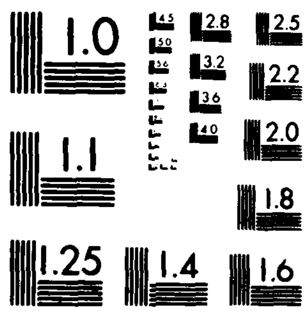

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Analysis of Methodologies for Assessment of Wetlands Values

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September 1981

U.S. Water Resources Council

TECHNICAL REPORT

ANALYSIS OF METHODOLOGIES USED FOR THE ASSESSMENT OF WETLANDS VALUES

FINAL REPORT

By

Robert I. Lonard, Ellis J. Clairain, Jr., Robert T. Huffman, J. W. Hardy,
Linda D. Brown, Paul E. Ballard, and Janet W. Watts

Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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Prepared for Director, U. S. Water Resources Council,
Suite 800, 2120L Street, NW
Washington, D. C. 20037

PREFACE

This is a final report based on a series of tools designed to identify and evaluate methodologies that assess inland and coastal wetland functions. The study was sponsored by the U. S. Water Resources Council and conducted by the Environmental Laboratory (EL), U. S. Army Engineer Waterways Experiment Station (WES). The study was accomplished by identifying methodologies presently used or under development that assess wetlands functional values and by preparing criteria and descriptive characteristics for a comprehensive analysis of selected evaluation methodologies. In addition the merits and limitations of each evaluation methodology were identified, instances where methodologies were lacking were noted, and recommendations for the improvement of consistency of wetlands evaluation methodologies were prepared.

Members of a WES study team charged to conduct the study included: Dr. Robert I. Lonard, Wetlands Research Associate, who was the principal author of this report; Mr. Ellis J. Clairain, Jr., Aquatic Biologist; Dr. Robert Terry Huffman, Research Botanist, Environmental Resources Division (ERD), Wetland and Terrestrial Habitat Group; J. W. Hardy, U. S. Fish and Wildlife Service; Linda D. Brown, Biological Technician; Paul E. Ballard, Biological Technician; and Janet W. Watts, Biological Technician. Editorial supervision was provided by Ms. Dorothy P. Booth.

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Mr. Carl Thomas
Soil Conservation Service
U. S. Department of Agriculture
Washington, D.C.

Mr. William Burris
Office of the Chief of Engineers
U. S. Army
Washington, D.C.

Mr. Robert Gallagher
Marine Fisheries
U. S. Department of Commerce
Washington, D.C.

Mr. Richard B. Mieremet
Office of Coastal Zone Management
U. S. Department of Commerce
Washington, D.C.

Mr. Steven Parker
Federal Energy Regulatory Commission
U. S. Department of Energy
Washington, D.C.

Mr. Charles Terrell
Aquatic Protection Branch
U. S. Environmental Protection Agency
Washington, D.C.

Mr. Bill Sipple
Aquatic Protection Branch
Criteria and Standards Division
U. S. Environmental Protection Agency
Washington, D.C.

Mr. John Christian
Chief, Policy and Legislation
U. S. Fish and Wildlife Service
Department of the Interior
Washington, D.C.

Mr. Fredrick Bank
Federal Highway Administration
U. S. Department of Transportation
Washington, D.C.

Mr. Robert B. Smythe
Council on Environmental Quality
Washington, D.C.

Mr. Donald Hammer
Tennessee Valley Authority
Norris, Tenn.

Mr. Albert Clark
Advisory Council on Historic
Preservation
Washingtn, D.C.

Mr. Curtis Chandler
Federal Emergency Management Agency
Federal Insurance Administration
Washington, D.C.

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Dr. Terry C. Allison
Department of Biology
Pan American University
Edinburg, Tex.

Mr. Paul Adamus
Center for Natural Areas
South Gardiner, Maine

Dr. James W. Buell
Consulting Biologist
Beaverton, Oreg.

Mr. J. Leonard Ledbetter
Director, Department of Natural
Resources
Environmental Protection Division
Atlanta, Ga.

Mr. Robert Lemaire (retired)
U. S. Army Engineer Division
Lower Mississippi Valley
Vicksburg, Miss.

Dr. Robert J. Reimold
Director, Coastal Resources Division
Georgia Department of Natural Resources
Brunswick, Ga.

Mr. Ken Fucik
Research Scientist
Science Applications, Inc.
Boulder, Colo.

Mr. Stephen W. Forsythe
Research Biologist
Wetland and Terrestrial Habitat Group
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

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Environmental Division
Board of Engineers for Rivers and
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Fort Belvoir, Va.

Dr. J. S. Larson
Department of Forestry and
Wildlife Management
University of Massachusetts
Amherst, Mass.

Dr. Richard C. Smardon
College of Environmental Science
and Forestry
Syracuse, N.Y.

Mr. William J. Hansen
Resource Analysis Group
Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

Mr. Arthur F. Doyle
U. S. Army Engineer Division New England
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U. S. Fish and Wildlife Department
Washington, D.C.

Dr. Hal Kibby and Dr. Bill Sanville
Environmental Research Laboratory
U. S. Environmental Protection Agency
Corvallis, Oreg.

Mr. Hal Moore
Environmental Branch
U. S. Army Engineer Division
Lower Mississippi Valley
Vicksburg, Miss.

Mr. Sherman L. Lewis
Soil Conservation Service
U. S. Department of Agriculture
Amherst, Mass.

Dr. Frank C. Golet
Department of Forest and Wildlife Management
University of Rhode Island
Kingston, R.I.

Mr. Brian Winchester
CH2M Hill
Gainesville, Fla.

Dr. John H. Foster
Department of Food and Resource Economics
University of Massachusetts
Amherst, Mass.

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Commander and Director of WES during the preparation of this report was COL Nelson P. Conover. CE. Technical Director was Mr. Fred R. Brown.

SUMMARY

The results of a research study designed to identify and evaluate methodologies that assess inland and coastal wetland functions are discussed in this report. Discussions include a critical review of the current literature, identification of research needs, recommendations of currently available wetlands evaluation methodologies, and recommendations to improve the consistency of wetlands evaluation methodologies.

The study included the following tasks, results, and recommendations:

a. Potential wetlands evaluation procedures were identified by state wetland management agencies, by members of the Wetland Evaluation Work Group of the Water Resources Council, and by members of the U. S. Army Engineer Waterways Experiment Station (WES), U. S. Army Corps of Engineers (WES) study team. Twenty documents were identified as potentially useful for the objectives of this study.

b. A screening criteria form and a series of descriptive characteristics were developed to ensure consistency during the analysis and multiple review process. Descriptive features included an analysis of wetland functions, geographic features, personnel needs, data requirements, and products, field testing, flexibility, and administrative uses. From these data a synoptic profile was developed for each pertinent evaluation methodology and a series of tables were developed to allow the user to compare wetlands evaluation methodologies. Recommendations of various evaluation instruments were made concerning the descriptive characteristics listed above.

c. The merits and limitations of each evaluation methodology were noted in the descriptive characteristics and profiles.

d. The results of the study indicate that there are limitations in the use of currently available wetlands evaluation instruments, but the current state of the art is best developed for habitat functions of wetlands.

e. Habitat functions of wetlands can be adequately assessed by either species-specific (U. S. Army Engineer Division, Lower Mississippi Valley (HES) 1980, or U. S. Fish and Wildlife (HEP) 1980) or biophysical methodologies, i.e. Golet (1973). Selection of an appropriate methodology should be based on the objectives and resources of the evaluator.

f. The state of the art in the evaluation of hydrology functions of wetlands is poorly developed because research efforts have not produced an adequate data base. The WES study team recommended that technical gaps should be identified that have implications to management needs. High priority should be given to the development of a research program that addresses technical gaps that are related to management needs.

g. The state of the art in the assessment of agriculture, silviculture, heritage, and recreation functions is open for improvement, but the WES study team did not propose specific recommendations.

h. Many wetlands evaluation instruments have been developed primarily for regional use and must be modified or adapted for other regions or other wetland types. The WES study team encouraged the development of more regional methodologies and specific wetland-type methodologies.

i. The WES study team recommended that personnel skill levels should be stated for new methodology development or for the improvement of existing methodologies.

j. The WES study team advocated the use of red flag features that emphasize important wetland values; however, red flag features should be developed that emphasize important wetland community types or for wetlands that indicate important hydrology values.

k. An important limitation of many wetlands evaluation instruments is the lack of field testing or the lack of information related to field testing results. However, the WES study team did not recommend an extensive field effort until inconsistencies of individual methodologies are improved.

l. The WES study team also recommended that state and Federal agencies with wetlands management responsibilities should identify and state their needs for specific wetlands evaluation instruments. This information should be conveyed to authors or potential authors of wetlands evaluation methodologies.

CONTENTS

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* Appendices C, D, and E are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

LIST OF FIGURES

LIST OF TABLES

ANALYSIS OF METHODOLOGIES USED FOR THE ASSESSMENT OF WETLANDS VALUES

PART I: INTRODUCTION

The U. S. Water Resources Council has formed a Floodplain Management Task Force to (a) oversee implementation of the recommendations set forth in a report entitled, "A United National Program for Floodplain Management"; (b) carry out the Council's evaluation responsibilities under Section 5 of the Floodplain Management Executive Order (E.O. 11988); and (c) respond to the Council's work program to improve coordination and integration of wetlands and floodplain management. With regard to the latter objective, one of the Council's programs is to conduct an analysis and comparison of wetlands evaluation methodologies in use or under development by Federal or state agencies, the academic community, or private consulting firms. Based on their analysis, the Task Force will make recommendations for improving the consistency and the utilization of existing wetlands evaluation methodologies. To accomplish their mission, the Task Force created an interagency Wetlands Evaluation Work Group to implement the wetlands evaluation program whereby the group sponsored a research study to identify and evaluate methodologies to assess wetlands functions. This study is being conducted by the Environmental Laboratory, U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss.

An analysis of wetland evaluation instruments is appropriate because state and Federal agencies have a variety of interests and management responsibilities with wetlands. From this analysis a resource manager evaluator may select a currently available methodology that evaluates specific wetland functions for administrative needs that include project planning and site selection, regulatory actions, impact assessments, management, mitigation, and acquisition needs. Each methodology is also analyzed for additional administration and technical features.

Purpose and Scope of the Study

The goal of the WES study has been to identify and evaluate methodologies that assess inland and coastal wetlands functions.

This study has been accomplished through the following actions:

a. Identification of methodologies presently used or under development to assess wetlands functional values.*

b. Preparation of criteria and descriptive characteristics for comprehensive analysis of selected evaluation methodologies.

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* Several wetlands evaluation methodologies are in the early stages of development and should be available in the future. These include methodologies being developed by the following: The State of Michigan; Virginia Institute of Marine Science (tidal flats); Environmental Protection Agency, Region 1; and the Center for Nat ral Areas.

c. Examination of the merits and limitations of each evaluation methodology and selection of those methodologies that warrant detailed study.

d. Identification of instances where methodologies are lacking or are of limited value for assessment of wetlands functional values.

e. Preparation of recommendations for the improvement of consistency of wetlands evaluation methodologies.

Methods

This study was organized into a series of four tasks as shown in Figure 1. Initially, state management agency personnel with wetlands management responsibilities were solicited to obtain a list of wetlands evaluation methodologies currently in use or under development. Twenty-five states were contacted and 17 state agencies responded by providing evaluation methodologies that assess inland or coastal wetland functions. Other potential documents were identified by the Wetlands Evaluation Work Group of the Water Resources Council and by members of the WES study team. Forty-two documents were identified as potential sources of methodologies for the assessment of functional values of wetlands (Appendix A). Two documents (Schuldiner et al. 1979a and Schuldiner et al. 1979b) were combined into one review and detailed analysis.

The WES study team was charged with the task of identifying methodologies that are used specifically to assess functional values of wetlands. Methodologies that were developed to assess nonwetland sites, but could include related wetland functions, were not included in the scope of the study. A document had to address one or more functions of wetlands that included habitat, hydrology, agriculture/silviculture, recreation, or heritage values (Appendix B). In addition, a nonmonetary assessment of wetlands values or wetland acreages was a requirement.

For the purposes of this report, the WES study team has utilized the definition of a "wetland" proposed by Cowardin et al. (1979) of the U. S. Fish and Wildlife Service.*

Screening criteria consisting of three evaluation standards were developed to ensure uniformity for the subsequent review and evaluation of the documents by the study team (Appendix C).** A document had to satisfy all the evaluation standards before a decision rationale was developed for a detailed analysis of descriptive characteristics and before subsequent profile development. Finally, in Task I, a series of descriptive characteristics were

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* Wetlands are defined as: "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."

** Appendices C, D, and E are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

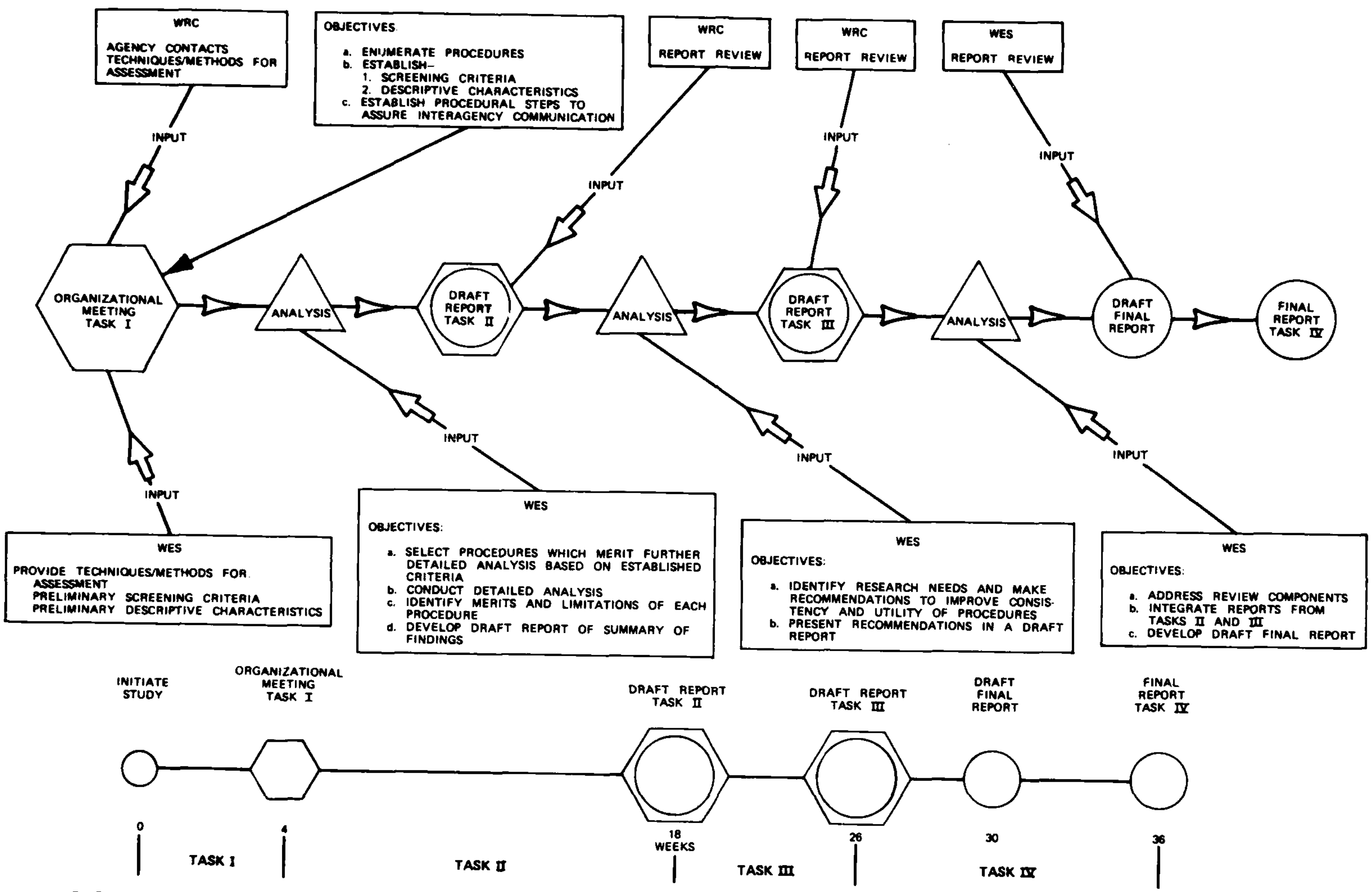

FIGURE 1. APPROACH AND SCHEDULE FOR ANALYSIS OF WETLAND EVALUATION PROCEDURES

prepared to categorize and display each evaluation procedure selected for detailed analysis (Appendix C).

During Task II of the project each document was examined by at least two members of the WES study team according to the screening criteria and evaluation standards. A comprehensive analysis was performed for each selected methodology according to the previously determined descriptive characteristics for the documents satisfying all screening criteria. These analyses are shown in Appendix C. No further analysis was performed on documents that did not satisfy all of the evaluation standards of the screening criteria (Appendix D).

Tables 1-8 provide a summary of 20 documents which met the screening criteria. Table 9 is a summary of those that failed to meet the criteria. Each document was examined by at least two members of the WES study team according to the screening criteria and evaluation standards. A single profile was prepared for each methodology from the information described above. Each profile is a summary of the salient features of the methodology or document examined (Appendix E). A glossary was developed prior to the evaluation to ensure consistency by members of the study team and to enhance user understanding (Appendix B).

In Task III the WES study team identified procedural gaps in existing methodologies and future research needs, and made recommendations to improve the consistency of wetland evaluation methodologies. Upon completion of this task, the technical report and appendices were submitted for peer review to the individuals listed in the preface section of this report. In addition, the technical report, multiple reviewer analysis, and methodology profile were submitted to each author or agency representative for review. Peer and author review comments have been incorporated, quoted, or footnoted in appropriate places in this report or in the appendices. Author agency responses are also noted in the preface section of this report.

PART II: RESULTS, RESEARCH NEEDS, AND RECOMMENDATIONS OF CURRENTLY AVAILABLE WETLANDS EVALUATION METHODOLOGIES

Wetlands Functions and Administrative Features

Table 1 and the profiles (Appendix D) present summaries of 20 documents that contained relevant evaluation methodologies of wetlands functional values. All of the methodologies addressed one or more wetlands functions that included habitat, hydrology, recreation, agriculture/silviculture, and heritage features (Appendix B, Glossary).

Habitat functions

The WES study team found that habitat is one of the more studied functional values of wetlands and is most often included in wetlands evaluation methodologies. Specific parameters to be measured for an evaluation of habitat functions are listed for 12 evaluation methodologies (Table 1, Brown et al. 1974; Fried 1974; Golet 1973; Larson (ed.) 1976; Reppert et al. 1979; Schuldiner et al. 1979; State of Maryland, Undated; U. S. Army Engineer Division, Lower Mississippi Valley 1980 (HES); U. S. Department of Agriculture 1978; U. S. Fish and Wildlife Service 1980 (HEP); Virginia Institute of Marine Science, Undated; and Winchester and Harris 1979). An interdisciplinary team is required to define and measure habitat parameters in at least four other methodologies (Table 1, Dee et al. 1973; Galloway 1978; Solomon et al. 1977; and U. S. Army Engineer Division, New England 1972). The use of an interdisciplinary team is encouraged in at least one other methodology (Table 1, U. S. Fish and Wildlife Service 1980 (HEP)).

The state of the art of the evaluation of wildlife habitat of wetlands is well developed. However, there is room for improvement because methodologies which relate habitat quality to wildlife populations are based on various assumptions. These assumptions often reflect gaps in present knowledge of habitat requirements for wildlife. The gaps identified pertaining to habitat evaluation methodologies are intended as an overview of the deficiencies in wetlands habitat evaluation methodologies in general and do not necessarily apply equally to each evaluation methodology identified and discussed.

Most authors have not identified key assumptions that form the basis of the development of a habitat evaluation methodology. For example, some specific assumptions are (but not necessarily stated in various methodologies) that selected groups of diverse species can be used as indicators of overall habitat quality, that vegetative structure defines habitat requirements, that some habitat requirements are more important than others, that there is a positive relationship between habitat diversity and wildlife species diversity, and that there is a positive relationship between vegetative interpretation and wildlife species diversity (New England Research, Inc. 1980).

Several wetlands evaluation methodologies that assess habitat functions are potentially useful for various administrative needs. An important feature is that no single method is clearly more valuable than others. Each methodology must be examined with respect to the objectives, to the parameters to be measured, to time and cost constraints, and to other restraints placed upon the user. A careful examination of Tables 1-8 should assist a user in a determination of which procedure best meets his needs and resources.

Hydrology functions

All primary wetlands functions are linked to the presence, movement, quantity, and quality of water in a wetland (Carter 1979). However, some aspects of secondary and tertiary production may not be totally linked to the hydrology of wetlands. (Personal Communication, 6 February 1981, Dr. Robert Reimold, Director, Coastal Resources Division, Brunswick, Georgia.) The hydrologic properties of wetlands are not understood well and are difficult to analyze because of the complexity of interrelated chemical, physical, and biological variables involved. Quantitative analyses of hydrologic functions that include water quality, groundwater recharge, and storm- and floodwater storage values require sophisticated techniques, instrumentation, and time requirements beyond the scope of most routine water resource planning or permit studies (Reppert et al. 1979).

The limited number of interpretative methodologies that can be used to evaluate hydrology functions in wetlands is due to a lack of knowledge of wetland hydrology, rather than the lack of emphasis on the part of authors of wetlands evaluation methodologies. Research has not resulted in a large, comparable data base. The data base concerning the hydrology of wetlands should be expanded (Larson and Loucks (ed.) 1978; Carter 1979; Stearns, Conrad, and Schmidt - Consulting Engineers 1979; and Reppert et al. 1979). Data are often contradictory or incomparable, are qualitative, and have been submitted to subjective interpretations (Stearns, Conrad, and Schmidt - Consulting Engineers 1979). Larson and Loucks (ed.) (1978) stated that the objectives of hydrology-related investigations are to (a) measure, (b) understand, (c) predict, and (d) manage the hydrology of a wetland area. If these objectives are not met, the formulation of a fully satisfactory evaluation instrument is not possible. In general, a broad-based comprehensive research program based on hydrologic principles and theories and directed toward the objectives of understanding, prediction, and management will be required before the hydrologic function is understood.

Carter et al. (1979) have recognized five specific research needs for identifying and quantifying hydrologic functions of wetlands. They include: (a) the need for improving and simplifying existing techniques for hydrologic measurements; (b) the need for the determination of hydrologic inputs and outputs of representative wetland types; (c) the need to improve the understanding of and to quantify soil-water-vegetation relationships of wetlands; (d) the need for long-term hydrologic studies of wetlands; and (e) the need to develop models based on hydrologic data. They indicated that sound criteria must be established for use in management decisions. Inferences must be made because the hydrology of all wetlands cannot be studied.

A goal of hydrology-related research in wetlands should be to establish a wetland evaluation system that will be useful in the assessment of hydrogeologic values. O'Brien and Motts (1980) have listed 29 hydrogeologically significant wetland factors and have suggested that combinations of these parameters should be identified and field tested to allow for the formulation of a hydrogeologic classification for wetlands. They suggested that it may be desirable to have several classification systems depending on the values that are sought for a wetland evaluation.

Specific parameters to be measured for an evaluation of hydrology functions are listed for seven evaluation methodologies (Table 1, Kibby 1978;

Larson (ed.) 1976; Reppert et al. 1979; Schuldiner et al. 1979; Stearns, Conrad, and Schmidt - Consulting Engineers 1979; U. S. Army Engineer Division, New England 1972; Winchester and Harris 1979). An interdisciplinary team is required to define and assess hydrology parameters in three additional methodologies (Table 1, Dee et al. 1973; Galloway 1978; and Solomon et al. 1977). Of the presently available wetlands evaluation methodologies that measure hydrologic functions, the WES study team recommends the methodology developed by Reppert et al. (1979) for a general wetlands evaluation of hydrologic functions and a methodology formulated by Schuldiner et al. (1979) for the assessment of impacts on the hydrology of wetlands.

The methodology developed by Reppert et al. (1979) utilizes many of the same hydrology-related parameters and criteria discussed in a literature review and analysis performed by Stearns, Conrad, and Schmidt - Consulting Engineers (1979). The Reppert team assigned qualitative values (i.e. high, moderate, or low values) for individual hydrology-related variables that included the parameters of water quality improvement, groundwater recharge, storm- and floodwater storage, and shoreline protection values.

The methodology formulated by Schuldiner et al. (1979) is useful in the evaluation of hydrology-related impacts because analytical methods that include baseline data needs, sampling and measuring techniques, data sources, and required expertise are stated for each parameter. The most common impacts to physical, chemical, and biological parameters are visually displayed in a series of flowcharts and matrices.

Agriculture/silviculture functions

Agriculture/silviculture functions of wetlands include harvest values of food or fuels and differ from hydrology and habitat functions in that the former provide direct human benefits from wetland resources. Many of the issues surrounding agriculture/silviculture functions are related to defining value or finding means to assess it (Niering and Palmisano 1979). The concept of harvest value of this function is straightforward; however, it is not easily applied to open systems such as wetlands. No methodology analyzed in this study documents the value of a wetland to the harvest of all wetland-dependent resources, but good data exist in other documents for standing crops of trees and agricultural crops (Niering and Palmisano 1979). Additional synoptic information is available on the production of peat and other energy sources, fur, fish, and fowl, and have been quantified. However, additional research is needed to determine the quantity of harvestable materials wetlands produce, factors that limit production, and the economics of harvest.

Nonwetlands evaluation methodologies may exist that provide techniques for the evaluation of wetland agriculture/silviculture functions. An analysis of such nonwetland methodologies, however, was not included in this study.

Only one wetlands evaluation methodology can effectively be utilized to evaluate silviculture functions of wetlands (Table 1, U. S. Department of Agriculture 1978). However, the methodology was developed for forest management practices in the coastal zone of Massachusetts and must be modified and adapted for use in other forested wetlands regions. None of the currently available wetlands evaluation methodologies can be used to assess agriculture functions.

Recreation and heritage functions

Few wetlands evaluation methodologies address recreation and heritage values of wetlands in detail. These functions differ from previously discussed wetlands values because they concern direct, usually nonconsumptive, human use and enjoyment of wetlands resources. Recreation and heritage functions include a wide variety of wetlands values that include canoeing, sport fishing, photography, bird watching, camping, etc., as well as historical, aesthetic, and cultural values.

Specific parameters are identified for an evaluation of recreation functions in only four methodologies (Table 1, Smardon 1972; U. S. Army Engineer Division, New England, 1972; U. S. Department of Agriculture 1978; and U. S. Fish and Wildlife Service (HEP), 1980). An interdisciplinary team is required to define and evaluate recreation functions in two other methodologies (Table 1, Reppert et al. 1979 and Solomon et al. 1977). Specific parameters for the evaluation of heritage functions were also identified in only four methodologies (Table 1, Gupta and Foster 1973; Larson (ed.) 1976; Smardon 1972; and U. S. Department of Agriculture 1978). An interdisciplinary team must determine heritage parameters in an additional five methodologies (Table 1, Dee et al. 1973; Galloway 1978; Reppert et al. 1979; Solomon et al. 1977; and U. S. Army Engineer Division, New England 1972).

Nonwetlands evaluation procedures that may provide more quantitative instruments to adequately assess recreation and heritage functions were not considered in this study; however, such methodologies may exist.

Niering and Palmisano (1979) have suggested that recreation and heritage functions can be measured by recreation specialists, landscape architects, social scientists, and other specialists. Basic data essential to the construction of evaluation procedures for these functions should be collected, integrated, and correlated by professionals in the disciplines listed above. Methodologies for assessing, rating, or scaling recreation and heritage functions then could be written. After field testing the evaluation methodologies, personnel who will be involved in the assessment of recreation and heritage functions should be trained in the fundamentals of the disciplines involved and in the practical use of the evaluation methodology.

Of the currently available wetlands evaluation methodologies that measure recreation functions, the WES study team recommends the evaluation instrument formulated by the U. S. Department of Agriculture (1978) for coastal areas of Massachusetts. It must be emphasized, however, that relatively few methodologies addressed this wetlands function and the methodology must be modified for widespread use.

Heritage functions are most adequately assessed by the evaluation instrument formulated by Smardon (1972) and subsequently included in a methodology compiled by Larson (ed.) (1976) for an assessment of freshwater wetlands in Massachusetts. Smardon's methodology could serve as a framework for the development of a larger evaluation instrument that includes other sociocultural functions of wetlands.

Geographic features

Regional methodologies have been developed primarily for inland glaciated areas in the Northeast, for coastal wetlands in the Southeast, for freshwater wetlands in the Lower Mississippi River drainage system, and for state use in Arkansas. Wetlands evaluation methodologies are currently unavailable for specific regions that include the West Coast, Alaska, Hawaii, Puerto Rico, or the Southwest. Wetlands types lacking evaluation methodologies include prairie potholes, playa lakes, vernal pools, and others.

Eight methodologies (Table 2, Fried 1974; Galloway 1978; Reppert et al. 1979; Schuldiner et al. 1979; Stearns, Conrad, and Schmidt - Consulting Engineers 1979; Solomon et al. 1977; U. S. Department of Agriculture 1978; and U. S. Fish and Wildlife (HEP) 1980) were identified that can be used, or adapted for use, in both inland and coastal wetlands. In general, these methodologies can be used for a wide variety of wetland types, although some are specific to either inland or coastal wetlands and would require major revisions to adapt them to a contrasting geographic site. Eight methodologies are relatively limited to regional or state use (Table 2, Brown et al. 1974; Fried 1974; State of Maryland, Undated; U. S. Army Engineer Division, New England 1972; U. S. Army Engineer Division, Lower Mississippi Valley (HES) 1980; U. S. Department of Agriculture 1978; and Winchester and Harris 1979). The remaining methodologies have fairly widespread applications ranging from possible use in several regions to nationwide applicability.

Personnel needs - administrative conditions.

The methodologies either require the expertise of an individual resource manager who has sufficient technical skills to perform a wetland evaluation or the collective expertise of an interdisciplinary team. The methodologies are nearly equally represented in categories that require an interdisciplinary team or a resource manager for decisionmaking. Where decisions are rendered by a resource manager, the decisionmaking process could be aided by the addition of specialists. An interdisciplinary team approach usually has extensive personnel requirements and is associated with long-term planning projects. In one methodology (Table 3, Galloway 1978), a team of laymen that represent local interests is included in addition to the resource manager and the interdisciplinary team. Implications relative to user needs for personnel requirements are summarized in Table 3.

Data requirements

A great deal of variation exists from methodology to methodology on basic data requirements (Table 4). Large-scale projects require extensive amounts of data and are usually associated with an interdisciplinary team approach. Small-scale projects, which are usually associated with regulatory actions, require smaller amounts of data and less sophisticated approaches. Nearly all methodologies require basic data that include various types of maps, aerial photographs, and information gained from field reconnaissance.

Most habitat-oriented methodologies require basic vegetation data. Methodologies that require habitat and hydrology information generally may have seasonal limitations on data collection. Most hydrology-related functions must be monitored at least seasonally for one year.

All methodologies include value judgements by either the resource manager or collective value judgements by an interdisciplinary team. For the purposes of this report, value judgements are viewed as being derived from field experiences and insights into the functions and values of wetland ecosystems. Value judgements are inherently a part of wetland evaluation methodologies. In most methodologies, quantitative data are used to make or corroborate value judgements. With the presently available methodologies, quantitative data are collected only for habitat functions and to a limited extent for hydrology functions. Implications relative to user needs for data requirements of wetlands evaluation methodologies are summarized in Table 4.

Flexibility - responsiveness

Three methodologies have the flexibility or responsiveness to generate quick answers with limited amounts of data and detailed or refined answers with more data (Table 6, Larson (ed.) 1976; Reppert et al. 1979; and U. S. Fish and Wildlife Service (HEP) 1980). Detailed answers are often associated with long-term or extensive projects and interdisciplinary team approaches. Quick answers for a wetlands evaluation usually are associated with regulatory actions and resource manager features. Six methodologies have some degree of flexibility to differentiate and assess major and minor impacts of activities in wetlands (Table 6, Dee et al. 1973; Galloway 1978; Schuldiner et al. 1979; Solomon et al. 1977; U. S. Army Engineer Division, Lower Mississppi Valley (HES) 1980; and U. S. Fish and Wildlife Service (HEP) 1980).

Red flag features

The authors of some wetlands evaluation methodologies have identified criteria that identify wetlands that should be preserved on the basis of their outstanding values. These criteria are generally referred to as "red flag" features. For example, red flag features of wetlands may include habitats for rare and endangered species or wetlands that are unique examples of geological phenomena, biological resources, or are of archeological significance (Larson (ed.) 1976).

Seven methodologies (Table 5, Dee et al. 1973; Galloway 1978; Larson (ed.) 1976; Reppert et al. 1979; Schuldiner et al. 1979; Smardon 1972; U. S. Army Engineer Division, New England 1972; and U. S. Fish and Wildlife Service (HEP) 1980) have some type of red flag features that identify key, sensitive wetlands functions. Red flag features of wetlands, therefore, may be important elements in a wetlands evaluation procedure because they can be used for promulgating the value of a particular wetland to the general public.

Galloway (1978) identified nine critical indicators of wetland quality but did not emphasize them as red flag features. In his methodology, six of the nine indicators would be selected and evaluated by an interdisciplinary team. Dee et al. (1973) suggested that an interdisciplinary team identify major and minor red flags in water resources development projects, but no direction was given to specifically identify sensitive functions.

The concept and use of red flag features are used extensively by Larson (ed.) (1976) and his coworkers (i.e., Gupta and Foster 1973; Smardon 1972). Schuldiner et al. (1979) have also used Larson's basic list of red flag features. In Larson's methodology, if a wetland has at least one red flag feature of eleven proposed red flags, the wetland should be strongly considered

for preservation. The argument against the use of the lengthy list of red flag features is that nearly all wetlands could be perceived as having at least one of the red flag features. The use of the red flag features is extremely subjective. According to Larson, further evaluation of a wetland should cease if at least one red flag feature is identified and the wetland could be placed in the "preservation category." The WES study team therefore recommends a more thorough wetland evaluation if an investigator adopts one of the methodologies that identifies red flag features.

End products - evaluation summary

Fourteen methodologies (Table 6, Brown et al. 1974; Dee et al. 1973; Fried 1974; Golet 1973; Gupta and Foster 1973; Larson (ed.) 1976; Reppert et al. 1979; Smardon 1972; State of Maryland, Undated; U. S. Army Engineer Division, Lower Mississippi Valley (HES) 1980; U. S. Department of Agriculture, 1978; U. S. Fish and Wildlife Service (HEP) 1980; Virginia Institute of Marine Science, Undated; and Winchester and Harris 1979) presented guidelines for converting qualitative or semiquantitative data into numerical values for a display of end products or as a manner of illustrating an evaluation summary of a wetland.

When an individual wetland is evaluated, a narrative report expressing high, moderate, or low value is the usual format (Table 6, Kibby 1978; Reppert et al. 1979; Stearns, Conrad, and Schmidt - Consulting Engineers 1979; and U. S. Army Engineer Division, New England 1972). One methodology (Table 6, Galloway 1978) relied extensively on computer-based facilities and presented an evaluation summary in the form of a graphic display. Another methodology could use a software computer program and provide results in a graphic display or could utilize the manual procedures (Table 6, U. S. Fish and Wildlife Service (HEP) 1980). Two methodologies with important applications for impact assessment had end products in the form of a flowchart and matrix or a coefficient matrix (Table 6, Schuldiner et al. 1979 and Solomon et al. 1977).

The use of wetlands evaluation numerical rating scales may be met with ambivalent feelings by some resource managers because wetlands with low numerical values may be difficult to defend in litigation or to defend from the "developer's bulldozer." However, numerical ratings may be an important method of communicating complex wetland data into a comprehensible form for decisionmakers in diverse fields of expertise.

Most authors of wetlands evaluation methodologies are very careful not to state numerical ranges that indicate relative quality of a wetland. The methodology developed by the U. S. Department of Agriculture (1978) for coastal wetlands in Massachusetts is an exception because low, moderate, and high values are associated with numerical ranges. Also, most authors are careful not to rate or rank different wetlands types in a hierarchical scheme. For an example, a bog would not ordinarily be rated with a marsh. Brown et al. (1974), however, have ranked diverse wetlands types in Arkansas by utilizing the same numerical scheme.

Field testing

A need exists for field testing of various wetlands evaluation methodologies (Table 5). Decisionmakers in both state and Federal agencies should be

actively involved in field testing methodologies in both freshwater and saltwater situations. A significant objective of field testing and subsequent improvement of evaluated methodologies is to generate better resource management decisions.

The HEP method developed by the U. S. Fish and Wildlife Service (1980) is one of the methodologies that evaluates habitat functions and encourages an interdisciplinary team approach. HEP is currently being used by field stations of the U. S. Fish and Wildlife Service as well as by various other governmental agencies and has been the most widely field tested evaluation instrument. The HES method, developed by the U. S. Army Corps of Engineers, Lower Mississippi Valley Division (1980), has been used extensively within the agency on a regional basis in the Lower Mississippi Valley. In 1980, the methodology was field tested in Mississippi, Kansas, and New Hampshire by New England Research, Inc. Both methodologies should be subjected to additional field testing and compared by various agencies because both are highly quantitative approaches and require extensive amounts of data for implementation.

For habitat evaluation methodologies that have applications to agency needs other than project planning and site selection, the WES study team recommends a field comparison of several basically qualitative approaches that require the services of resource managers, namely Golet (1973), U. S. Department of Agriculture (1978), and possibly others if time and resources are available. However, all of these approaches currently have regional applications.

It is recommended that several "general purpose" methodologies that evaluate a variety of wetland functions be field tested and compared in various regions of the United States. These include methodologies developed by Galloway (1978); Larson (ed.) (1976); and Reppert et al. (1979). Of these, the methodology developed by Larson is not applicable to coastal wetlands.

Methodologies that evaluate specific individual functions such as hydrology, recreation, silviculture, or heritage should be field tested more extensively. However, because of a lack of a variety of evaluation instruments, comparisons are difficult to make. The user should refer to the WES study team's comments about specific methodology recommendations.

Applicability of methodologies to agency needs

Tables 7 and 8 provide summaries of wetlands evaluation methodologies that may be used for various agency administrative needs. Agency requirements include project planning and site selection, regulatory actions, impact assessments, management, mitigation, and acquisition needs. It must be emphasized, however, that most authors of evaluation methodologies have not specifically identified administrative needs for which a methodology was developed. The WES study team has attempted to answer this question by stating basic requirements for different administrative activities and then by placing specific methodologies into those category requirements (Table 8).

Eight methodologies were identified as being applicable to project planning and site selection needs (Table 7, Dee et al. 1973; Galloway 1978; Schuldiner et al. 1979; Stearns, Conrad, and Schmidt - Consulting Engineers

1979; Solomon et al. 1977; U. S. Army Engineer Division, Lower Mississippi Valley (HES) 1980; U. S. Fish and Wildlife Service (HEP) 1980; and U. S. Army Engineer Division, New England 1972). All of these methodologies require or encourage the expertise of an interdisciplinary team and include a range of low to high data requirements and high or defined levels of accuracy. The same methodologies are also associated with impact assessment needs with the exception of the methodologies of the Stearns, Conrad, and Schmidt - Consulting Engineers (1979) and U. S. Army Engineer Division, New England (1972).

The methodologies that are useful for regulatory actions are generally those that are tailored to generate answers in short periods of time and require moderate levels of technical skills, data requirements, and degrees of accuracy. These methodologies usually require the expertise of a resource manager. Eleven methodologies have been identified that address regulatory actions (Table 7, Brown et al. 1974; Golet 1973; Gupta and Foster 1973; Kibby 1978; Larson (ed.) 1976; Reppert et al. 1979; Smardon 1972; State of Maryland, Undated; U. S. Department of Agriculture 1978; Virginia Institute of Marine Science, Undated; and Winchester and Harris 1979, and Table 8).

Six methodologies have been identified for on-site impact assessment needs (Table 7, Dee et al. 1973; Galloway 1978; Schuldiner et al. 1979; Solomon et al. 1977; U. S. Army Engineer Division, Lower Mississippi Valley (HES) 1980; and U. S. Fish and Wildlife Service (HEP) 1980, and Table 8). All require the expertise of an interdisciplinary team to differentiate and assess major and minor impacts. Impact assessments usually were made in a generalized fashion.

Seven methodologies were identified that are applicable to management needs (Table 7, Brown et al. 1974; Golet 1973; Larson (ed.) 1976; State of Maryland, Undated; U. S. Fish and Wildlife Service (HEP) 1980; U. S. Army Engineer Division, Lower Mississippi Valley (HES) 1980; and Virginia Institute of Marine Science, Undated, and Table 8). These methodologies are related to habitat functions and with some exceptions have moderate time, technical skill data requirements, and degrees of accuracy features. Only two of the methodologies (HES and HEP) require the expertise of an interdisciplinary team.

Twelve methodologies are applicable to mitigation needs because they generally do not require extensive time levels, expertise, data, or degree of accuracy attributes (Table 7, Brown et al. 1974; Fried 1974; Golet 1973; Larson (ed.) 1976; Reppert et al 1979; Schuldiner et al. 1979; Smardon 1972; State of Maryland, Undated; U. S. Army Engineer Division, Lower Mississippi Valley (HES) 1980; U. S. Fish and Wildlife Service (HEP) 1980; Virginia Institute of Marine Science, Undated; and Winchester and Harris 1979). The methodologies developed by Schuldiner et al. (1979); U. S. Army Engineer Division, Lower Mississippi Valley (HES), (1980); and U. S. Fish and Wildlife Service (HEP) (1980) require higher levels of expertise and degree of accuracy requirements but their applications to mitigation needs are discussed.

Eleven methodologies are applicable to acquisition needs for preservation of wetlands. With some exceptions they also do not require extensive amounts of time, high levels of expertise, large amounts of data, or high levels of accuracy for implementation (Table 7, Brown et al. 1974; Fried 1974; Golet 1973; Gupta and Foster 1973; Larson (ed.) 1976; Smardon 1972; State of Maryland, Undated; U. S. Army Engineer Division, Lower Mississippi Valley (HES)

1980; U. S. Department of Agriculture 1978; U. S. Fish and Wildlife Service (HEP) 1980; and Winchester and Harris 1979). The methodology developed by Fried (1974) was specifically formulated for acquisition applications in the State of New York and includes a discussion of monetary values of wetlands.

Description of Documents Not Meeting the Evaluation Criteria

Table 9 presents summaries of 21 documents that did not satisfy the screening criteria and evaluation standards. The documents were either not methodologies for evaluating wetlands functions, or evaluated wetlands solely on a monetary basis.

Fourteen documents did not provide methodologies for evaluating wetlands (Table 9, Bara et al. 1977; Belknap and Furtado 1967; Benson and Perry 1965; California Coastal Commission 1979; Commonwealth of Virginia 1974; Coordinating Council on the Restoration of the Kissimmee River Valley and the Taylor Creek-Nubbin Slough Basin 1978; Foster 1978; Fritz 1978; Gupta 1972; Larson 1973; New York State Department of Environmental Conservation Undated; Silberhorn et al. 1974 ; U. S. Department of Agriculture 1974; and Williams and Works 1979. Three of the documents in this category were guidelines for reviewing permit applications (Table 9, Bara et al. 1977; California Coastal Commission 1979; and Commonwealth of Virginia 1974). Five documents did not identify wetland functions (Table 9, Battelle-Pacific Northwest Laboratories 1974; Belknap and Furtado 1967; Foster 1978; U. S. Environmental Protection Agency 1976; and Whitaker and McCuen 1975), and nine documents contained methodologies that evaluated wetlands on a monetary basis (Table 9, Belknap and Furtado 1967; Benson and Perry 1965; Coordinating Council on the Restoration of the Kissimmee River Valley and the Taylor Creek-Nubbin Slough Basin 1978; Foster 1978; Gosselink et al. 1974; Gupta 1972; Hill 1976; Shabman et al. 1979; and Wharton 1970).

PART III: RECOMMENDATIONS TO IMPROVE METHODOLOGIES FOR THE EVALUATION OF WETLANDS VALUES

Evaluation of the functional values of wetlands is largely dependent upon agency needs, time requirements, manpower, and economic constraints. In addition, the state of the art in the development of wetlands evaluation methodologies has not reached the point where any one of the available methodologies is clearly superior to another. Based on the findings of this study, it is recommended that wetlands evaluation methodologies be improved along the following guidelines.

Discussion of Recommendations

Habitat functions

The state of the art of wetlands evaluation methodologies is best developed for habitat functions, although a number of technical gaps exist. A variety of both qualitative and quantitative approaches currently exist that are potentially useful for administrative needs.

The potential methodology user should refer to Tables 1 through 8 for a closer examination of methodology characteristics and requirements. Methodologies developed by the U. S. Fish and Wildlife Service (1980) (HEP) and by the U. S. Army Engineer Division, Lower Mississippi Valley (1980) (HES) as well as methodologies developed by various states (i.e., State of Maryland, Undated) are being subjected to rigorous field testing situations. These methodologies are being refined and improved on the basis of field testing results. This is evident by assessing the changes and improvements in the HEP and HES methodologies during the past few years. The WES study team believes that significant progress is being made in the improvement of wetlands habitat evaluation instruments for wildlife value and does not recommend specific research programs at this time.

In the future, species-specific methodologies (HEP and HES) that require quantitative data and biophysical methodologies (i.e., Golet 1973) that generally have qualitative data requirements, should be compared. These approaches have different assumptions and philosophies and the potential for integration of these methodology approaches should be explored (Larson, In Press). Also, in the future, research efforts should be directed to an ecosystem approach which integrates biotic, abiotic, and human-associated factors in habitat analysis (New England Research, Inc. 1980).

Hydrology functions

The state of the art in the evaluation of hydrology functions of wetlands (including floodwater conveyance, wave energy dissipation, groundwater recharge, and water quality maintenance) is poorly developed because basic research efforts have not produced a large data base and data are often contradictory or incomparable. Most of the hydrology-related data have been obtained for water surface levels for lakes, streams, and reservoirs rather than wetlands. However, the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station at Vicksburg, Miss., is currently developing hydrologic models of the Atchafalaya River Basin in Louisiana.

Techniques have not been developed for assessing the value of a wetland as it relates to flood control. In addition, studies concerning the relationships of individual wetlands to flood control values have not been conducted in unglaciated regions outside the Northeast (Larson, In Press).

The importance of hydrology functions of wetlands is also of critical importance in the future in the area of human health and welfare. Acute water shortage problems and the contamination of groundwater aquifers have emphasized the need to obtain technical information about the hydrology of wetlands.

Storm damage abatement values of various wetland types require further study before this hydrology function is used as a basis for management decisions. Experimental evidence of the value of this function is contradictory for the limited amount of studies that have been conducted in coastal and inland wetlands (Silberhorn et al. 1974, Tilton et al. 1978).

The hydrology-related function of water quality control of wetlands is difficult to assess because present techniques are crude and imprecise. A critical need exists for translating the available knowledge into methodologies that can be used for making wetlands management decisions (Larson, In Press).

It has also been assumed that freshwater wetlands generally recharge groundwater aquifers. However, only under some conditions can groundwater aquifers be recharged by wetlands. Basic research is needed in unglaciated areas outside the Northeast in a variety of wetland types before this function can be established (Larson, In Press).

For the reasons stated above, management decisions concerning hydrology functions of wetlands are often made on the basis of incorrect, incomplete, or contradictory information. Therefore, the WES study team recommends a two-phased approach to improve the pressing management needs related to the state of the art in the evaluation of hydrology functions as follows:

a. Important scientific or technical data gaps should be exactly identified with their implications to management or decision-making needs. The methodology writer should consult the U. S. Geological Survey for current documents.

b. Upon completion of the initial task, high priority should be given to the development of a specific research program that addresses technical gaps as they are related to management needs.

Only after these two objectives are accomplished can methodologies be improved for the evaluation of hydrology functions of wetlands. Based on the current limitations in the technical hydrology-related data base, the methodologies developed by Reppert et al. (1979) are probably most applicable to potential users at the present time.

Agricultural functions

Nonwetland methodologies that address the issue of agricultural values of wetlands were not analyzed in this study. Therefore, the WES study team has not made any recommendations concerning this function.

Silvicultural functions

In the future the demand for wood products will likely create pressure on silviculture functions of wetlands. Pressure will be exerted to log wetland areas as other forest areas disappear. The WES study team, therefore, recommends that research efforts should be directed toward ways to obtain natural forest products without harming or destroying other wetlands values.

Heritage functions

The WES study team has no recommendations for the improvement of methodologies related to heritage functions of wetlands. The Water I sources Council had planned an assessment of the state of the art and had planned to develop Environmental Quality Measurement procedures for heritage functions. If the study is reinstituted, it may result in recommendations for the improvement of methodologies for the assessment of this function.

Recreation functions

The current state of the art in the assessment of recreation functions of wetlands is open for improvement, but the WES study team has not proposed any recommendations at this time. In the future, basic data necessary for the development of wetlands evaluation methodologies should be collected by a team of recreation specialists. After data collection, integration, and correlation, methodologies could be written and further refined after field testing.

Geographic features

Many of the available wetlands evaluation instruments have been developed for regional use in the coastal areas of the Southeast, for the glaciated areas of the Northeast, or for the Lower Mississippi River Basin. Some of the methodologies that were developed for widespread use may be difficult to adapt for specific geographic areas or specific wetland sites. The WES study team, therefore, recommends that methodologies that were developed for widespread application should serve as a framework for an assessment of wetland values. However, criteria and parameters that emphasize specific regions and wetland types should be developed for inclusion into methodologies that were developed for widespread use. For example, data and evaluation are needed for coastal areas in the Gulf of Mexico, for prairie potholes, for playa lakes, for Alaska, for Puerto Rico, for vernal pools, and other areas for which evaluation instruments are unavailable.

Personnel requirements

The WES study team recommends that personnel skill levels be stated for new methodology development or for improvement of existing methodologies. Most of the current methodologies that require interdisciplinary teams allude to specific personnel requirements, but for those methodologies that require only a resource manager, skill levels are not stated.

Data requirements and methodology flexibility

Data requirements and methodology flexibility are functions of the scale of the proposed project. Methodologies that have short time requirements and

minimal data requirements are concomitant with short, unrefined answers. The converse is true for those projects that require extensive time requirements. Data requirements are generally spelled out fairly well in the currently available procedures. Therefore, the WES study team has no specific recommendations to improve these features of wetlands methodologies.

Red flag features

Larson (1976) used a concept of red flag features for freshwater wetlands in glaciated areas of the Northeast as part of decisionmaking model. Red flag features were used to designate wetlands that merit preservation. His concept, which has been adopted by other investigators (i.e., Schuldiner et al. 1979), could be used in an inclusive sense that could designate nearly all wetlands for preservation. In the Larson concept of red flag features, a wetland evaluation would be terminated if one or more red flag features are discovered.

The WES study team advocates the use of red flag features but recommends that they be used in a different sense. For example, red flag features should be developed that alert a resource manager to important wetland community types or to wetlands that could have important hydrology values. In this sense a resource manager could be alerted to potentially important habitat values if highly productive plant communities are identified. A resource manager could be alerted also to wetlands that may have significant hydrology functions if red flags are developed that indicate strategic positions of wetlands in a floodplain for flood control or of wetland types that may have a potential source of potable water. Red flag features, in this sense, could also be developed for other wetland functions. However, these red flag features would be used to indicate wetlands that require further detailed analysis. A wetland would require additional analysis before it would possibly be considered for preservation.

Field testing

A limitation of some wetland evaluation methodologies is the lack of field testing experiments or the lack of information related to field testing results. In some of these methodologies, potential inconsistencies have not been identified because of the lack of field testing experiments. Therefore, the WES study team believes that a well organized, comparative field testing program is premature at the present time until the inconsistencies and technical problems of more methodologies are identified and improved.

Field testing experiments should continue on individual methodologies. Methodologies that were developed for widespread use should be field tested in various geographic locations and wetland types in order to identify problem areas and to subsequently refine the methodologies. The methodologies should be tested by Federal as well as state agencies in the future.

Agency needs

Wetland evaluation methodologies may need improvements related to their applicability to agency needs. The WES study team recommends that various state and Federal agencies that are involved in wetlands management activities assess and elaborate on their needs for specific evaluation instruments to authors of methodologies.

Summary of Recommendations

In summary the WES study team has made the following recommendations for the improvement of methodologies for the evaluation of wetland values:

a. Progress is being made in the improvement of wetlands habitat evaluation instruments and no specific actions are recommended at this time.

b. The WES study team recommended a two-phased approach to improve the assessment of hydrology values of wetlands that included the identification of scientific data gaps and the development of a specific research program that addresses technical gaps as they are related to management needs.

c. The WES study team did not make any specific immediate recommendations concerning agriculture, recreation, and heritage functions of wetlands. However, the study team recommended actions that should be considered in the future.

d. The WES study team recommended research efforts directed toward obtaining forest products from wetlands by causing minimal impacts on other wetland values.

e. Criteria and parameters that emphasize specific wetland types and regions should be developed for inclusion into methodologies that were originally developed for widespread use.

f. Personnel skill levels should be stated for new or existing methodologies.

g. Data requirements are spelled out fairly well for most wetlands evaluation procedures; therefore, no recommendations were made to improve this feature of evaluation instruments.

h. Red flag features should be used to indicate wetlands that require further detailed analysis.

i. A well organized field testing program should not be conducted at the present time until inconsistencies of individual methodologies are identified and improved. Field testing experiments should continue on individual methodologies in a variety of geographical areas and wetland types.

j. The WES study team recommended that various state and Federal agencies involved in wetlands management activities assess and communicate their needs for specific evaluation instruments to authors of methodologies.

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Table 1

Summary of Critical Elements to be Measured for an Assessment of Functional Values for 20 Wetland Evaluation Procedures

Methodology Number	Citation	Habitat*	Hydrology**	Recreation†	Agriculture/Silviculture††	Heritage
1	Brown, A., et al. 1974	Classification of prime and nonprime wetlands, life forms and sublife forms, classification according to use by man, wetland habitat classes and subclasses, size classes, wetland site types, surrounding habitat types, wetland cover types, wetland interspersion, wetland juxtaposition	NA	NA	NA	NA
2	Dee, N., et al. 1973	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured	NA	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured
3	Fried, E. 1974	(1) Biological productivity: total alkalinity, area with 6"-24" water depth, adjacent soil fertility, Soil Conservation Service Wildlife Suitability rating, vegetative interspersion, number of vegetative classes, plant species, fish and wildlife species, (2) vulnerability rating, and (3) additional factors	NA	NA	NA	NA
4	Galloway, G. E. 1978	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured	NA	NA	Interdisciplinary team must decide critical elements to be measured

(Continued)

Note: NA. Not addressed.

* Habitat. Habitat functions include the related categories of common wetland plant and animal species, endangered, threatened, or rare plant and animal species, game species, commercial species, and nongame species.

** Hydrology. Hydrology functions include floodwater storage, shoreline protection, ground and surface water recharge and discharge, and water quality.

† Recreation. Recreation functions include water-required activities such as boating, sport fishing, photography, nature study, camping, etc.

†† Agriculture/Silviculture. These functions include harvestable products of wetlands such as cultivated crops, pastureland and hay crops, lumber, peat, etc.

Heritage. Heritage functions include scenic, cultural, scientific, visual, and aesthetic values of wetlands.

(Sheet 1 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
5	Golet, F. C. 1973	Wetland class richness, dominant wetland class, size category, subclass richness, site type, surrounding habitat type, cover types, vegetative interspersion, wetland juxtaposition, water chemistry	NA	NA	NA	NA
6	Gupta, T. R., and Foster, J. H. 1973	NA	NA	NA	NA	Scenic values: land form contrast, land form diversity, land use contrast, wetland type diversity, wetland size, water body size
7	Kibby, H. V. 1978	NA	Water quality: frequency of hydrologic periodicity, estimation of net primary productivity	NA	NA	NA
8	Larson, J. S., ed. 1976	Wetland class richness, dominant wetland class, size category, subclass richness, site type, cover types, vegetative interspersion, wetland juxtaposition	Presence of a useful water supply: base flow, test borings, surficial geology, ground water potentiometric map, drilling, and pumping sites	NA	NA	Land form contrast, land form diversity, wetland-edge complexity, associated water body size, diversity of associated water bodies surrounding land use contrast, surrounding land use diversity, wetland type diversity, internal wetland contrast, wetland size
9	Reppert, R. T., et al. 1979	Productivity and food chain relations: net primary productivity, mode of detrital transport, food chain support, determination of key game, commerical, aesthetic species	Hydrologic periodicity, shoreline protection (vegetation, width, fetch, cultural development), flood water storage (vegetative cover), natural groundwater storage (soil depth, porosity, transmissivity, etc), water quality improvement (type of wetland, areal and waste loading relationships), geographical and locational factors	Investigator's professional judgment	Investigator's professional judgment	Investigator's professional judgment

(Continued)

(Sheet 2 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
10	Schuldiner, P. W., et al. 1979	Potential biological impacts on wetlands: change in wetland size, change in species composition, change in class composition, change in primary productivity and secondary productivity, sudden mortality of aquatic species, barrier to animal movements, encouragement of beaver activity, rare and endangered species	Potential impacts on physical properties: (1) Impacts associated with surface flows (change in mean water level, change in periodicity, change in wetland circulatory patterns), (2) Impacts associated with subsurface flows (alteration of local water table levels), (3) Impacts associated with creation of channels (drainage of surface waters, periodic flooding, and fertilization change in retention storage), (4) Impacts associated with tidal flows (damping of tidal variations, alteration of salinity patterns), (5) Impacts associated with water quality (turbidity, sedimentation, chemical pollution, temperature patterns)	NA	NA	NA

(Continued)

(Sheet 3 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
11	*Stearns, Conrad, and Schmidt - Consulting Engineers.* 1979	NA	(1) Water quality improvement (vegetation types, wetland size, water residence time and velocity, hydraulic loading, wetland location), (2) Groundwater recharge (soils, wetland size, evapotranspiration rate, vegetation, wet/dry cycles, presence of a multi-aquifer system, water quality, retention time), (3) Storm and flood water storage (area soils and water table, vegetation, roughness, topography), (4) Shoreline protection (extent and type of vegetation, soils, frequency of inundation, location and elevation of wetland, fetch, bottom roughness, cultural developement)	NA	NA	NA
12	*Smardon, R. C.* 1972	NA	NA	Recreational carrying capacity, recreational diversity	NA	Visual-cultural values: land form contrast, land form diversity, wetland edge complexity, associated water body size, diversity of associated water bodies, surrounding land use contrast and diversity, wetland type diversity, internal wetland contrast, wetland size, multiple cultural attributes
13	Solomon, R. C., et al. 1977	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured	NA	Interdisciplinary team must decide critical elements to be measured

(Continued)

(Sheet 4 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
14	State of Maryland, Dept of Natural Resources. Undated	Net primary production, wildlife food value, vegetation/water interspersion variable, vegetation form vegetation interspersion	NA	NA	NA	NA
15	U. S. Army Engineer Division, Lower Miss. Valley (HES). 1980	A. Aquatic ecosystem evaluation 1. Streams: sinuosity, fish species associations, turbidity, total dissolved solids, chemical type, benthic diversity. 2. Lakes/lentic habitats: mean depth, turbidity, total dissolved solids, chemical type, shoreline development, spring flooding, fish standing crop B. Terrestrial ecosystem evaluation 1. Wooded swamps - bottomland hardwoods: species association, percent overstory, percent area inundated, ground cover - understory coverage, mast proximity, tract size, number of trees more than 16 in. DBH, number of snags. 2. Terrestrial wildlife value of aquatic habitats: cover by aquatic plants distance to disturbance, water depth in August, distance to river, brush cover, flooding frequency, winter overflow, distance from woods, size of water body, and shallow water. Also evaluates seasonally overflowed bottomland hardwoods	NA	NA	NA	NA

(Continued)

(Sheet 5 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
16	U. S. Army Engineer Division, New England. 1972	Interdisciplinary team must decide critical elements to be measured; detailed analysis of wildlife in the watershed project area	Flood water storage: basic hydrologic analyses for determining storage contained in lakes and wetlands of watershed. Flow duration frequency, storage yield, dependability, peak discharge frequencies, past flood analysis	Estimated annual user days for various activities, inventory of recreation site supply, and analysis of activities and demands in the watershed	Interdisciplinary team must decide critical elements to be measured; detailed analysis required for present and projected activities in watershed	Interdisciplinary team must decide critical elements to be measured; detailed analysis required
17	U. S. Department of Agriculture. 1978	Fish habitat: principle wetland type, size, location of wetland, presence of fish cover, presence of game fish. Wetland wildlife habitat: principle wetland type, number of wetland types, diversity of adjacent land use, percent of perimeter with 300' wide buffer strip, size, islands	Flood control: (estimations) effective storage of wetland on total watershed above, effective storage of upstream reservoirs and wetlands on total watershed, effective storage on main stem between wetland and potential damage area or major confluence, distance downstream to potential damage area, severity of potential flood damage	Boating: principal wetland type used for boating, acreage, physical access, boatable stream present. Fishing: principal wetland type, wetland size, physical access. Nature study: diversity of plants and animals, percent of urban development within 300 ft of wetland perimeter. Hunting: waterfowl hunting, access for hunting	Forest management, percent public ownership of forest in wetland, stand size, portion of forest land with 81-100 percent crown closure, portion of wetland forested, predominant forest cover type, shape of forested wetland, type of soil, accessibility	Uniqueness: location, endangered species habitat, regionally rare plant community, migratory birds, size, archaeological, geological, or historical significance. Visual quality: number of public roads, overlooks accessible by path, deciduous woodland type, topography, islands, appearance and condition, wetland types
18	U. S. Fish and Wildlife (HEP). 1980	1. Determine applicability of HEP. 2. Define study limits. 3. Determine baseline habitat units. a. Definition of study area. b. Delineation of cover types. c. Selection of evaluation species. 4. Compare baseline areas. 5. Determination of future habitat units. 6. Comparison of proposed actions	NA	NA	NA	NA

(Continued)

(Sheet 6 of 7)

Table 1 (Concluded)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
19	Virginia Institute of Marine Science. Undated	Vegetative production, wildlife food value, diversity of plant species, percent of marsh flooded daily, relative length of marsh-water interface	NA	NA	NA	NA
20	Winchester, B. H. and Harris, L. D. 1979	Determination of wetland size, wetland contiguity, vegetative structural diversity, and the type and amount of edge relative to wetland size	Determination of wetland size, wetland configuration, wetland contiguity, edge area relationships	NA	NA	NA

(Sheet 7 of 7)

Table 2

Summary of the Geographic Features of 20 Wetland Evaluation Procedures

Methodology Number	Citation	Inland*	Coastal**	Regional Application†	Widespread Application††	Use
1	Brown, A., et al. 1974	Yes; a variety of inland wetland types	NA	Developed for wetlands in Arkansas	Must be modified for widespread application	Can be used to assess a single wetland site. Can be used to rank similar or dissimilar wetland types
2	Dee, N., et al. 1973	Used for water resource development projects on rivers or river systems; could be modified for wetlands	NA	Applicable	Applicable	More useful for an assessment of a single wetland area
3	Fried, E. 1974	Applicable to freshwater wetlands and wetland restoration projects	Developed for tidal wetlands but has not been used for that purpose	Developed for wetland acquisition studies in New York	Must be modified for use in other regions	More useful for ranking wetlands
4	Galloway, G. E. 1978	Applicable to a variety of wetland types	Applicable to coastal wetlands and estuaries	Applicable	Applicable	Applicable for use in inland and coastal areas
5	Golet, F. C. 1973	Applicable to a variety of wetland types	NA	Developed for Mass. and useful in the general region	Applicable but must be modified for use outside the NE	Applicable for use in inland and coastal areas
6	Gupta, T. R., and Foster, J. H. 1973	Applicable	NA	Developed for Mass. and useful in the general region	Applicable but must be modified for use outside the NE	Applicable for use in inland and coastal areas
7	Kibby, H. V. 1978	Applicable to wetlands adjacent to rivers	NA	Applicable	Applicable	More useful for a narrative evaluation of a single wetland site

(Continued)

Note: NA. Not addressed.
* Can the procedure be used to evaluate a variety of inland wetland types?
** Can the procedure be used to evaluate a variety of coastal wetland types?
† Was the procedure developed for regional use?
†† Was the procedure developed for widespread application?

(Sheet 1 of 3)

Table 2 (Continued)

Methodology Number	Citation	Inland	Coastal	Regional Application	Widespread Application	Use
8	Larson, J. S., ed. 1976	Applicable	NA	Developed for Mass. and useful in the general region	Applicable but *must be modified for use outside the NE*	Applicable for both requirements; *comparison of wetlands in same general region*
9	Reppert, R. T., et al. 1979	Applicable	Applicable	Applicable	Applicable	Applicable for use in inland and coastal areas
10	Schuldiner, P., et al. 1979	Applicable	Applicable	Applicable	Applicable	Applicable for an assessment of a single wetland
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	Applicable	Applicable	Applicable	Applicable	Applicable for use in inland and coastal areas
12	Smardon, R. C. 1972	Applicable	NA	Developed for Mass. and useful in the *general region*	Applicable but *must be modified for use outside the NE*	Applicable for use in inland and coastal areas
13	Solomon, R. C., *et al.* 1977	Applicable, but developed for Water Resources projects	Possibly applicable, but developed for Water Resources *projects*	Applicable	Applicable	Applicable for use in inland and coastal areas
14	State of Maryland, Dept of Natural Resources. *Undated*	NA	Applicable	Developed for Maryland and useful in the general region	Must be modified for use in coastal zones outside the region	Applicable for both requirements, but comparisons must be made of wetlands in the same salinity regime
15	U. S. Army Engineer Division, Lower Miss. Valley (HES). 1980	Applicable, but developed for Water Resourced planning projects	NA, but salt marshes will be evaluated in future revision of procedure	Ecosystems in the Lower Mississippi River Valley	*Can be modified for use in other regions*	*Developed to be used in comparing project impacts or alternatives on existing and future "without"*

(Continued)

(Sheet 2 of 3)

Table 2 (Concluded)

Methodology Number	Citation	Inland	Coastal	Regional Application	Widespread Application	Use
16	U. S. Army Engineer Division, New England. 1972	Applicable, but unique to eastern Mass.	NA	Applicable for specific study site in eastern Mass.	NA	Not easily modified to assess and rank several wetlands
17	U. S. Department of Agriculture. 1978	Applicable	Applicable	Developed for Mass. and useful in general region	Can be modified for use in other regions	Applicable for use in inland and coastal areas
18	U. S. Fis[illegible] and Wildlife Service. 1980 1980	*Developed for inland* terrestrial and aquatic habitats	Not extensively applied to estuarine systems, but concepts may be applicable	Applicable	Applicable	Useful for evaluating baseline conditions and impacts in a single wetland. Also designed to rank habitats as to their wildlife values
19	Virginia Institute of Marine Science. Undated	NA	Applicable to tidal wetlands	Developed for tidal wetlands in Virginia	May be difficult to modify for use in other coastal regions	Applicable for use in inland and coastal areas
20	Winchester, B. H., *and* Harris, L. D. 1979	Applicable	NA	Developed for freshwater wetlands in Florida	Could be modified and used in noncoastal wetlands of the southeastern coastal plain	Applicable for use in noncoastal wetlands

(Sheet 3 of 3)

Table 3

Summary of Salient Features of 20 Evaluation Procedures for Personnel Needs

Methodology Number	Citation	Resource Manager*	Interdisciplinary Team**	Implications Relative to User Needs
1	Brown, A., et al. 1974	Yes	No	Experts should be consulted concerning specific problems
2	Dee, N., et al. 1973	No	Yes	The composition of the interdisciplinary team is dependent upon the nature of the Water Resources project but will include biologists, social scientists, and physical scientists
3	Fried, E. 1974	Yes	No	Technical assistance from plant and animal ecologists would facilitate the acquisition of habitat-related data
4	Galloway, G. E. 1978	No	Yes	Minimum requirements for an interdisciplinary team include an ecologist, botanist, zoologist, hydrogeologist, and a social scientist. In addition, the procedure requires a panel of laymen. Computer facilities are required
5	Golet, F. C. 1973	Yes	No	The resource manager should have a good background in wildlife biology, ecology, and plant systematics

(Continued)

* Does the procedure require a resource manager for decisionmaking?
** Does the procedure require an interdisciplinary team for decisionmaking?

(Sheet 1 of 4)

Table 3 (Continued)

Methodology Number	Citation	Resource Manager	Interdisciplinary Team	Implications Relative to User Needs
6	Gupta, T. R., and Foster, J. H. 1973	Yes	No	Scenic values of wetlands could be evaluated fairly rapidly by a resource manager without requiring special training in the use of the procedure
7	Kibby, H. V. 1978	Yes	No	A technician would be helpful if field estimation of net primary productivity is required. A resource manager could make general evaluations of water quality without a specialized training requirement
8	Larson, J. S., ed. 1976	Yes	Yes, under certain conditions	A resource manager who can read maps and use stereo-aerial photographs is usually the only personnel requirement
9	Reppert, R. T., et al. 1979	Yes	No	The resource manager may require field and laboratory assistance to implement the procedure. It will be difficult for a resource manager to evaluate all functions

(Continued)

(Sheet 2 of 4)

Table 3 (Continued)

Methodology Number	Citation	Resource Manager	Interdisciplinary Team	Implications Relative to User Needs
10	Schuldiner, P. W., et al. 1979	No	Yes	The interdisciplinary team should include ecologists, hydrologists, planners, geologists, limnologists, chemical engineers, soil scientists, biologists, and zoologists
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	No	Yes	The interdisciplinary team should include hydrologists, biologists, chemists, climatologists, sanitary engineers, and possibly others
12	Smardon, R. C. 1972	Yes	No	Visual-cultural values could be evaluated fairly easily by a resource manager without requiring special training in the use of the procedure
13	Solomon, R. C., et al. 1977	No	Yes	The interdisciplinary team should include an ecologist, economist, engineer, sociologist, and an anthropologist
14	State of Maryland. Dept of Natural Resources. Undated	Yes	No	A resource manager with a background in wildlife biology and plant ecology is required
15	U. S. Army Engineer Division. Lower Miss. Valley (HES). 1980	No	Yes	The interdisciplinary team* should include chemists, hydrologists, limnologists, ecologists, wildlife biologists, and botanists

* The authors have indicated that the interdisciplinary team should include fish and/or wildlife biologists. Other needed data available in literature and district files.

(Continued)

(Sheet 3 of 4)

Table 3 (Concluded)

Methodology Number	Citation	Resource Manager	Interdisciplinary Team	Implications Relative to User Needs
16	U. S. Army Engineer Division. New England. 1972	No	Yes	The procedure requires an interdisciplinary team composed of hydrologists, ecologists, economists, engineers, historians, archeologists, outdoor recreational planners, and others
17	U. S. Department of Agriculture. 1978	Yes	No	An interdisciplinary team comprised of a plant ecologist, hydrologist, ichthyologist, wildlife biologist, recreation specialist, and a landscape architect could facilitate the evaluation. However, only a professional natural resource planner is required
18	U. S. Fish and Wildlife Service (HEP). 1980	Yes	No*	A certified HEP evaluator is required
19	Virginia Institute of Maine Science. Undated	Yes	No	A resource manager with a background in plant and animal ecology is the only personnel requirement
20	Winchester, B. H., and Harris, L. D. 1979	Yes	No	A resource manager with a general technical background is the only personnel requirement

* Not required in HEP, but encouraged by the U. S. Fish and Wildlife Service by all its employees who use HEP.

(Sheet 4 of 4)

Table 4

Summary of the Data Requirements of 20 Wetland Evaluation Procedures

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
1	Brown, A., et al. 1974.	Aerial photographs, topographic maps, surficial geology maps, pertinent literature, and field reconnaissance	Value judgments and quantitative information	None	Resource manager should consult specialists for the interpretation of critical data
2	Dee, N., et al. 1973.	Obtained from historical records or from several different measurements that are related; topographic maps, wildlife lists, plant species lists, cultural, historical, and educational/scientific information	Interdisciplinary team assigns points to parameters. Parameter weights are assigned by quantifying research team's subjective value judgments	None stated, but seasonal limitations may be imposed on the collection of some data	Disagreements may occur over the relative values of the parameters
3	Fried, E. 1974	Aerial photographs, maps, alkalinity determinations, species lists, vegetative interspersion, vegetation classes, and vegetative cover	Value judgments and quantitative information	None stated, but possibly seasonal limitations	A resource manager may be necessary to edit results obtained by field workers
4	Galloway, G. E. 1978	Extensive data requirements dependent upon the type of parameters chosen to evaluate; preliminary data include maps and detailed species lists	Interdisciplinary team utilizes value judgments and quantitative data. A team of laymen is required to weigh parameter values	None	The procedure is time-consuming and requires extensive coordination between and among the team of scientists and laymen

(Continued)

(Sheet 1 of 5)

Table 4 (Continued)

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
5	Golet, F. C. 1973.	Aerial photographs, topographic maps, surficial geology maps; full reconnaissance to obtain wetland subclasses, vegetative interspersion, and water chemistry data	Value judgments and quantitative data	None	Resource manager must be familiar with vegetation and have a good background in wildlife management
6	Gupta, T. R., and Foster, J. H. 1973.	Maps and aerial photographs, limited field data	Value judgments are converted into numerical values	None	The procedure may be too superficial for general use
7	Kibby, H. V. 1978.	Determination of wetland size, periodicity of water exchanges, work review, net primary productivity data	Primarily value judgments, but some quantitative data	None	The procedure may be too superficial for general use
8	Larson, J. S., et al. 1976.	Extensive data requirements; maps, aerial photographs, transmissity, water storage, and water quality data	Value judgments and quantitative data	None	Procedure results should be monitored carefully for assessment of red flag features
9	Reppert, R. T., et al. 1979.	Maps, charts, aerial photographs, plant and animal species lists, basic hydrology data	Value judgments and quantitative data	None	Additional personnel are likely needed to collect and interpret data

(Continued)

(Sheet 2 of 5)

Table 4 (Continued)

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
10	Schuldiner, P. W., et al. 1979	Extensive data requirements, plant and animal lists, primary and secondary productivity, basic hydrology data, determination of potential impacts	Value judgments and quantitative data	Basic hydrology data must be collected periodically for at least one year	The user must be willing to commit large amounts of time and resources to an evaluation
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	Extensive hydrology related data requirements, annual water budgets, evapotranspiration rates, mass loadings, etc.	Value judgments based primarily on qualitative data	Hydrology data must be collected on a seasonal basis for at least one year	Extensive amounts of field and laboratory equipment are necessary to implement the procedure
12	Smardon, R. C. 1972	Topographic maps, aerial photogrammetric land use information, cover maps, surficial and bedrock, geology maps, and data obtained from field inspections	Primarily value judgments	None	The user may need training in general principles before the procedure is applied
13	Solomon, R. C., et al. 1977	Interdisciplinary team must decide data requirements	Value judgments and quantitative data	None	The procedure requires large amounts of time, resources, and coordination for implementation
14	State of Maryland. Department of Natural Resources.	Maps, aerial photographs, and field vegetative data	Value judgments and quantitative data	None, but seasonal limitations may be placed on the identification of plant species	The resource manager must be familiar with vegetation and wildlife food value of various plants

(Continued)

(Sheet 3 of 5)

Table 4 (Continued)

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
15	U. S. Army Engineer Division, Lower Miss. Valley (HES). 1980	Extensive amounts of habitat data; species lists, plant cover, vegetation sampling, data maps, etc.*	Focus on quantitative data; value judgments placed on habitat value	None stated; but seasonal limitations are imposed for some parameters**	Personnel should be trained and certified before attempting to utilize the procedure†
16	U. S. Army Engineer Division, New England. 1972.	Extensive date requirements, wildlife resources, hydrology, hydraulics, geology, demography, archeology, etc.	Value judgments based primarily on floodwater storage capacity of wetlands	Seasonal and possibly other limitations	The Charles River project required extensive citizen participation; the project had extensive time and cost requirements
17	U. S. Department of Agriculture. 1978.	Maps, field analysis, forest management practices, flood control information, species lists, rare and endangered species lists	Value judgments and quantitative information; primarily value judgments	None	The procedure may be too superficial for certain uses. Only a generalized evaluation is possible
18	U. S. Fish and Wildlife Service (HEP). 1980.	Aerial photographs, determination of plant cover types, species lists, topographic maps, photogrammetric information, and water gauging station records	Focus on quantitative data; value judgments placed on habitat value	None	Personnel must be trained and certified before the procedure can be used successfully

(Continued)

* "Limited amount of terrestrial habitat data easily acquired on plots by biologists. Most stream and lake data in the literature." (Author comment.)

** "However system allows for these limitations." (Author comment.)

† "but detailed instruction will allow its use without extensive training." (Author comment.)

(Sheet 4 of 5)

Table 4 (Concluded)

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
19	Virginia Institute of Marine Science. Undated	Reports, maps, aerial photographs, onsite inspections	Value judgments and quantitative data	None	Procedure is limited to applications only in coastal tidal marshes that are flooded daily
20	Winchester, B. H., and Harris, L. D. 1979	Aerial photgraphs, plant and animal species lists, data concerning vegetative structural diversity	Primarily value judgments	None	Results obtained may be too superficial and generalized for some purposes. A rapid evaluation is possible from limited amounts of data

(Sheet 5 of 5)

Table 5

Summary of the Red Flag Features and the Extent of Field Testing of 20 Wetland Evaluation Procedures

Methodology Number	Citation	Red Flag Features--Assessment of Red Flag Features*	Extent of Field Testing**	Need for Field Testing
1	Brown, A., et al. 1974	None	14 wetland sites in Arkansas were evaluated and ranked by the authors	Additional field testing by other individuals is desirable
2	Dee, N., et al. 1973	Elements of the environment that may be changed adversely are represented as major or minor red flags. Interdisciplinary team must make determinations	Field tested in a portion of the Bear River project in Utah, Idaho, and Wyoming by the Battelle Laboratory	Field testing specifically for potential impacts in wetlands is needed. Procedure was developed for large-scale Water Resources projects
3	Fried, E. 1974	None	Field testing was conducted by 12 field workers in various regions of New York. 130 wetlands were noted during 1973	Additional field testing results would be useful
4	Galloway, G. E. 1978	Nine critical indicators of wetland quality were proposed. Interdisciplinary team selects 6 of the 9 that best represent wetland under consideration. Presence of endangered species, fish and other aquatic ecosystems, wildlife and other terrestrial ecosystems, waterfowl, uniqueness, appearance, natural protection, life-cycle support, and historical-cultural. Only the endangered species category may be a red flag feature	The procedure has not been field tested; hypothetical examples were given	Field testing is needed

(Continued)

* Does the procedure have "red flag" features; features that emphasize key, sensitive wetland functions?
** Has the procedure been field tested and what has been the extent of field testing?

(Sheet 1 of 4)

Table 5 (Continued)

Methodology Number	Citation	Red Flag Features--Assessment of Red Flag Features	Extent of Field Testing	Need for Field Testing
5	Golet, F. C. 1973	Not listed here, but red flags are included in the author's contribution to a document published later (see Larson, ed. 1976)	Field testing was not discussed in the document	Field testing is needed
6	Gupta, T. R., and Foster, J. H. 1973	None listed, but red flags were included in a document published later by members of the research team (see Larson, ed. 1976)	Field testing was not discussed	Field testing is needed
7	Kibby, H. V. 1978	None listed	Field testing was not discussed	Field testing is needed
8	Larson, J. S., ed. 1976	Eleven red flag features are proposed: (1) the presence of rare, restricted, endemic, or select flora or fauna, (2) presence of flora of unusually high visual quality and infrequent occurrence, (3) the presence of flora or fauna at, or very near, the limits of this range, (4) the juxtaposition, in sequence, of several stages of hydrarch succession, (5) high production of native waterfowl species, (6) use by great numbers of migratory birds, (7) outstanding geomorphological features, (8) availability of information concerning the wetland, (9) presence of outstanding archeological evidence, (10) wetlands that are relatively scarce in a given physiographic region, and (11) wetlands that are links in a system of waterways....Theoretically all wetlands may contain red flag features. Investigators could tend to place all wetlands in a "preservation category." A detailed wetland evaluation (Phases II and III) should be performed	Field testing results not stated. Methodology applied in modified form by Soil Conservation Service in Mass., in Rhode Island (wildlife model), and in the Northeast and Lake states.	Field testing is needed

(Continued)

(Sheet 2 of 4)

Table 5 (Continued)

Methodology Number	Citation	Red Flag Features--Assessment of Red Flag Features	Extent of Field Testing	Need for Field Testing
9	Reppert, R. T, et al. 1979	Endangered or threatened species	EPA and Corps of Engineers field tested the procedure during training courses in 1977. Results were not discussed. EPA has used the procedure in Pennsylvania	Additional field testing is needed
10	Schuldiner, P. W., et al. 1979	The authors used the same red flag features proposed by Larson (ed.) 1976; an extensive list of red flags was proposed	Field testing (conducted at 8 sites in the U. S.) involved retrospective analyses of wetlands in which highway-induced changes had already taken place	Additional field testing is needed
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979.	None	None	Field testing is needed
12	Smardon, R. C. 1972	The author used essentially the same red flag features that were proposed by Larson (ed.) 1976	Field testing was conducted by the author in inland wetlands in Mass.	Additional field testing is needed
13	Solomon, R. C., 1977	None	The procedure was field tested on the Tensas project	Additional field testing is needed
14	State of Maryland. Dept of Natural Resources. Undated	None	Previous field testing in Maryland resulted in the formulation of the current procedure	Additional field testing is needed

(Continued)

(Sheet 3 of 4)

Table 5 (Concluded)

Methodology Number	Citation	Red Flag Features--Assessment of Red Flag Features	Extent of Field Testing	Need for Field Testing
15	U. S. Army Engineer Division. Lower Miss. Valley (HES). 1980	None	HES is being used by all districts in the Lower Mississippi Valley Division (St. Louis, Memphis, Vicksburg, and New Orleans)	Field testing by other agency personnel would be useful; was tested by New England Research, Inc., for IWR in 1980
16	U. S. Army Engineer Division. New England. 1972	Wetland had to be at least 100 acres and have a capacity to store large volume of floodwater	Field testing has not been conducted outside the project area of the Charles River, Mass.	The project was unique to the region and field testing is likely not possible for other regions
17	U. S. Department of Agriculture. 1978	None	Field testing was conducted by Soil Conservation Service and Mass. Water Resources personnel in Mass.; 223 wetlands were evaluated	Additional field testing would be useful
18	U. S. Fish and Wildlife Service (HEP). 1980	Identifies species sensitive to land use actions, species with key roles in the ecological community, a species representing groups of species utilize a common resource	The procedure has been tested by U. S. Fish and Wildlife Service during its development; currently being tested by the Corps of Engineers and the U. S. Fish and Wildlife Service	Further testing should be done to evaluate assumptions which are the basis of HEP
19	Virginia Institute of Marine Science. Undated	None	Results of possible field testing were not discussed in the report	Field testing is needed
20	Winchester, B. [illegible]., and Harris, L. D. 1979	None	Field testing has been conducted by the authors	Additional field testing should be conducted by state and federal agencies

(Sheet 4 of 4)

Table 6

Summary of the End Products and the Responsiveness Features of 20 Wetland Evaluation Procedures

Methodology Number	Citation	End Products*	Responsiveness** Quick Answers	Responsiveness** Detailed Answers	Does Procedure Assess Major and Minor Impacts†
1	Brown, A., et al. 1974	Numerical ranking of similar or dissimilar wetland types	Relatively quick answers	Only one type of answer is possible	NA
2	Dee, N., et al. 1973	Numerical rating expressed in environmental impact units; scores with and without proposed project	No	Detailed answers only	Yes

(Continued)

Note: NA. Not addressed.
* What type of end products or what type of evaluation summary is provided by the procedure?
** Does the procedure have the responsiveness or flexibility to provide quick answers from limited data and refined answers from additional data? It is assumed that a quick answer may be obtained within one day to one week; it is assumed that a detailed answer may require more than one week of effort; it is assumed that a relatively quick answer can be obtained with about a week of effort.
† Does the procedure differentiate and assess major and minor impacts of activities in wetlands? Only on-site impacts are considered.

(Sheet 1 of 5)

Table 6 (Continued)

Methodology Number	Citation	End Products	Responsiveness: Quick Answers	Responsiveness: Detailed Answers	Does Procedure Assess Major and Minor Impacts
3	Fried, E. 1974	A numerical priority rating value of per-acre desirability for wetland acquisition	Relatively quick answers	No	NA
4	Galloway, G. E. 1978	Graphic displays; computer printouts of numerical values	No	Yes	Yes; major and minor impacts could be identified by interdisciplinary team or by the team of laymen
5	Golet, F. C. 1973	Numerical rating of relative wildlife value	Relatively quick answers	Only one type of answer is possible	No
6	Gupta, T. R., and Foster, J. H. 1973	Numerical rating of scenic value	Yes	No	No
7	Kibby, H. V. 1978	Narrative report; subjective determination of wetland effects on water quality	Yes	No	No
8	Larson, J. S., ed. 1976	Numerical rating that includes values for a number of wetland functions	Yes	Yes	No††

(Continued)

†† J. S. Larson has indicated that the procedure is useful for assessing major and minor impacts.

(Sheet 2 of 5)

Table 6 (Continued)

Methodology Number	Citation	End Products	Responsiveness: Quick Answers	Responsiveness: Detailed Answers	Does Procedure Assess Major and Minor Impacts
9	Reppert, R. T., et al. 1979	Narrative summary when only one site alternative is available; numerical rating if several wetlands are compared	Yes	No	No
10	Schuldiner, P. W., et al. 1979	Matrix and flow charts of ecological consequences of construction activities	No	Yes	Yes; procedure is very effective in assessing major and minor impacts
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	Ratings of high, moderate, or low potential for various hydrology functions	No	Yes, general qualitative answers	No
12	Smardon, R. C. 1972	Numerical ratings for visual-cultural values	Relatively quick answers	Only one type of answer possible	No
13	Solomon, R. C., et al. 1977	Coefficient matrix which identifies the most beneficial or least detrimental project alternatives	No	Yes	Yes; primary, secondary, and tertiary impact levels are identified

(Continued)

(Sheet 3 of 5)

Table 6 (Continued)

Methodology Number	Citation	End Products	Responsiveness: Quick Answers	Responsiveness: Detailed Answers	Does Procedure Assess Major and Minor Impacts
14	State of Maryland. Dept of Natural Resources. Undated	Numerical ratings of habitat values	Relatively quick answers	No	No
15	U. S. Army Engineer Division. Lower Miss. Valley (HES). 1980	Weighted rating values with a comparison of baseline conditions with future without project conditions, with future project conditions and with future alternative conditions	Relatively quick answers	Yes	Yes
16	U. S. Army Engineer Division. New England. 1972	The end product of the project was acquisition of wetlands	No	Yes	No
17	U. S. Department of Agriculture. 1978	Some numerical values with designated high, moderate, and low ratings for various functions; an evaluation summary sheet	Relatively quick answers	No	No‡

(Continued)

‡ The U. S. Soil Conservation Service has indicated that the procedure is useful for impact assessment.

(Sheet 4 of 5)

Table 6 (Concluded)

Methodology Number	Citation	End Products	Responsiveness: Quick Answers	Responsiveness: Detailed Answers	Does Procedure Assess Major and Minor Impacts
18	U. S. Fish and Wildlife Service (HEP). 1980	A matrix of relative quality values which may be used to give numerical comparisons, predictions, and baseline assessments; tables and forms	Relatively quick answers	Yes	Yes; assessment of gain or loss of habitat quality with and without proposed action overtime
19	Virginia Institute of Marine Science. Undated	Numerical rating of relative ecological significance	Relatively quick answers	No	No
20	Winchester, B. H., and Harris, L. D. 1979	Numerical rating	Yes	Yes	No

(Sheet 5 of 5)

Table 7

Summary of the Applicability Features to Various Types of Administrative Needs of 20 Wetland Evaluation Procedures

Methodology Number	Citation	Project Planning and Site Selection	Regulatory Actions	Impact Assessment	Management	Mitigation	Acquisition Needs for Preservation
1	Brown, A., et al. 1974	Not applicable; evaluation on only habitat functions	Applicable; does not have extensive time requirements, requires moderate to low technical skills, data, and degree of accuracy	Not applicable	Some application	Applicable; alternative wetlands may be identified	Applicable; high quality wetlands could be identified by the ranking process
2	Dee, N., et al. 1973	Applicable; developed for long-term Water Resources projects, interdisciplinary team approach	Not applicable; requires extensive amounts of time	Applicable; determine major and minor impacts a[illegible] project alternatives	Not applicable	Not applicable	Not applicable
3	Fried, E. 1974	Not applicable	Not applicable	Not applicable	Not applicable	Applicable; may be useful for making "trade-offs"	Applicable; specifically developed for acquisition needs in New York; procedure also contains a separate economic evaluation instrument
4	Galloway, G. E. 1978	Applicable; requires extensive time requirements, graphic display of evaluation results	Not applicable	Applicable; impacts determined for various sites in wetland and watershed; utilizes expertise of interdisciplinary team, laymen, and project engineer	Not applicable	Not applicable	Not applicable
5	Golet, F. C. 1973	Not applicable	Applicable (habitat values); no extensive time or data requirements	Not applicable	Applicable; can be used to manage for maximum wildlife production and diversity	Applicable; numerical ranking may identify wetlands for possible "trade-offs"	Applicable; high quality wetlands may be identified for possible acquisition

(Continued)

* Table 8 further describes these administrative needs.

(Sheet 1 of 4)

Table 7 (Continued)

Methodology Number	Citation	Project Planning and Site Selection	Regulatory Actions	Impact Assessment	Management	Mitigation	Acquisition Needs for Preservation
6	Gupta, T. R., and Foster, J. H. 1973	Not applicable	Applicable; must be used in conjunction with other procedures because only scenic values are evaluated	Not applicable	Not applicable	Not applicable	Applicable; wetlands of outstanding scenic quality could be identified for purchase
7	Kibby, H. V. 1978	Not applicable	Applicable; does not require extensive time requirements, technical skills, or high degree of accuracy to produce general evaluation of water quality	Not applicable	Not applicable	Not applicable	Not applicable
8	Larson, J. S., ed. 1976	Not applicable**	Applicable; numerous functions are evaluated in a time- and cost-efficient manner	Not applicable**	Applicable; submodels in the procedure may be useful (habitat); management of visual-cultural attributes	Applicable; numerical ranking instrument may allow "trade-offs"	Applicable; high quality wetlands could be identified by "red flag" features
9	Reppert, R. T., et al. 1979	Not applicable†	Applicable; a narrative evaluation summary can be prepared in a short time frame	Not applicable	Limited application	Applicable; lower quality wetlands could be identified for alternative development sites	Limited application; high quality wetlands not specifically "earmarked"

(Continued)

** J. S. Larson indicated that the procedure is applicable to project planning and site selection and impact assessment.
† R. T. Reppert has indicated that the methodology is applicable for preliminary project planning.

(Sheet 2 of 4)

Table 7 (Continued)

Methodology Number	Citation	Project Planning and Site Selection	Regulatory Actions	Impact Assessment	Management	Mitigation	Acquisition Needs for Preservation
10	Schuldiner, P. W., et al. 1979	Applicable; requires extensive time requirements, large amounts of data, high degree of accuracy, and technical skills for biological and hydrological functions	Not applicable	Applicable; determination of high, moderate, and low impacts of physical structures on habitat and hydrology values of wetlands	Not applicable	Applicable; procedure specifically identifies mitigation practices to avoid or reduce impacts	Not applicable
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	Applicable; requires extensive amounts of time, expertise, and accuracy for implementation. A thorough hydrological investigation is required	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
12	Smardon, R. C. 1972	Not applicable	Applicable; no extensive time or technical skill requirements	Not applicable	Not applicable	Applicable; trade-offs may be possible by an identification of low quality wetlands	Applicable; high quality wetlands can be identified from red flag features
13	Solomon, R. C., et al. 1977	Applicable (Water Resource projects); extensive time, expertise, and degree of accuracy requirements	Not applicable	Applicable; interdisciplinary team determination	Not applicable	Not applicable	Not applicable
14	State of Maryland. Dept of Natural Resources. Undated	Not applicable	Applicable; time, cost, technical skill, and degree of accuracy requirements are moderate (habitat)	Not applicable	Applicable; for site-specific management needs	Applicable; numerical rankings may be useful	Applicable; may be used to identify high quality wetlands

(Continued)

(Sheet 3 of 4)

Table 7 (Concluded)

Methodology Number	Citation	Project Planning and Site Selection	Regulatory Actions	Impact Assessment	Management	Mitigation	Acquisition Needs for Preservation
15	U. S. Army Engineer Division, Lower Miss. Valley (HES). 1980	Applicable	Not applicable††	Applicable	Applicable for assessing alternative management plans	Not applicable	Applicable for determining habitat value for acquiring mitigation lands
16	U. S. Army Engineer Division, New England. 1972	Applicable; requires extensive time, costs, expertise, and levels of accuracy for implementation	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
17	U. S. Department of Agriculture. 1978	Not applicable	Applicable; can be used to evaluate a variety of functions in a cost- and time-efficient fashion	Not applicable‡	Not applicable	Not applicable	Applicable; high quality wetlands could be identified for possible purchase
18	U. S. Fish and Wildlife Service (HEP). 1980	Applicable; usually requires extensive time and costs. Requires expertise and identifies levels of accuracy for application	Applicable‡‡	Applicable	Applicable	Applicable; can be used to determine acreage needed to maintain habitat quality level and best means to offset potential loss in quality	Applicable
19	Virginia Institute of Marine Science. Undated	Not applicable	Applicable	Not applicable	Applicable	Applicable	Not applicable
20	Winchester, B. H., and Harris, L. D. 1979	Not applicable§	Applicable; does not require extensive time, expertise, and data requirements	Not applicable	Not applicable	Some application	Possible application; numerical rankings may be useful for determination of high quality wetlands

†† "Can be used to evaluate impacts on wetlands." (Author comment.)
‡ The U. S. Soil Conservation Service has indicated that the methodology is applicable to impact assessment.
‡‡ The authors have indicated that the procedure is applicable to regulatory needs but is frequently limited because of the time requirement and manpower funding limitations. A decision must be based on individual user needs.
§ The author indicated that the methodology is relevant to project planning and site selection.

(Sheet 4 of 4)

Table 8

Summary of Administrative Needs, Basic Administrative Requirements, and Available Wetland Evaluation Procedures that Address Administrative Needs

Administrative Needs	Time	Basic Requirements: Technical Skills	Basic Requirements: Data	Degree of Accuracy	Pertinent Wetland Evaluation Procedures
Project planning and site selection	Long (years)	High	High	High	U. S. Fish and Wildlife Service, 1980 (habitat); U. S. Army Engineer Division, Lower Mississippi Valley, 1980 (habitat); Dee, et al., 1973; Galloway, 1978; Schuldiner, et al., 1979 (hydrology and biological impacts); Stearns, Conrad, and Schmidt - Consulting Engineers, 1979; Solomon, et al., 1977; U. S. Army, New England, 1972
Regulatory actions	Short, days or 1-3 months	Moderate	Low to moderate	Moderate	Brown, et al., 1974 (habitat); Golet, 1973 (habitat); Gupta and Foster, 1973 (scenic value); Kibby, 1978 (water quality); Larson, ed., 1976; Reppert, et al., 1979; Smardon, 1972 (visual-cultural); State of Maryland (habitat); U.S.D.A., 1978; Virginia Institute of Marine Science (habitat); Winchester and Harris, 1979 (habitat); U. S. Fish and Wildlife Service, 1980 (habitat), (see note in Table 7)
Impact assessment	Short to moderate	Moderate	Moderate	Moderate	Dee, et al., 1973; Galloway, 1978; Schuldiner, et al., 1979 (hydrological and biological impacts); Solomon, et al., 1977; U. S. Fish and Wildlife Service, 1980 (habitat); U. S. Army Engineer Division, Lower Mississippi Valley, 1980 (habitat)

(Continued)

Table 8 (Concluded)

Administrative Needs	Time	Basic Requirements: Technical Skills	Basic Requirements: Data	Degree of Accuracy	Pertinent Wetland Evaluation Procedures
Management	Short to moderate	Moderate	Moderate	Moderate	Brown, et al., 1974 (habitat); Golet, 1973 (habitat); Larson, ed., 1976; State of Maryland (habitat); Virginia Institute of Marine Science (habitat); U. S. Fish and Wildlife Service, 1980 (habitat); U. S. Army Engineer, Division, Lower Mississippi Valley, 1980 (habitat)
Mitigation Requirements	Short to moderate	Moderate	Low to moderate	Low to moderate	Brown, et al., 1974 (habitat); Golet, 1973 (habitat); Fried, 1974 (habitat); Larson, ed., 1976; Reppert, et al., 1979; Schuldiner, et al., 1979; Smardon, 1972 (visual-cultural); State of Maryland (habitat); Virginia Institute of Marine Science (habitat); U. S. Fish and Wildlife Service, 1980 (habitat); U. S. Army Engineer Division, Lower Mississippi Valley, 1980 (habitat)
Acquisition Needs for Preservation	Several months to one year	Moderate	Moderate	Moderate	Brown, et al., 1974 (habitat); Golet, 1973 (habitat); Fried, 1974 (habitat); Gupta and Foster, 1973 (scenic value); Larson, ed., 1976; Smardon, 1972 (visual-cultural); State of Maryland (habitat); U.S.D.A., 1978; Winchester and Harris, 1979 (habitat); U. S. Fish and Wildlife Service,1980 (habitat), U. S. Army Engineer Division, Lower Mississippi River Valley, 1980 (habitat)

Table 9

Summary of Documents Not Meeting Evaluation Criteria

Methodology Number	Citation	Methodology*	Wetland Functions**	Nonmonetary Assessment†	Decision Rationale
a	Bara, M. O., et al. 1977	No	Yes	Yes	Document provides guidelines for reviewing permit applications in South Carolina, but the purpose of the document was not to evaluate wetland functions
b	Battelle-Pacific Northwest Laboratories. 1974	Yes	No	Yes	Procedure was designed for the evaluation of social, economic, and environmental trade-offs in the analysis of nuclear plant siting options
c	Belknap, R. K., and Furtado, J. G. 1967	No	No	No	Document is a review of three other works. No wetland functions are specifically evaluated
d	Benson, D., and Perry, R. F. 1965	No	Yes	No	Document does not contain a procedure for evaluating wetlands. Wetland functions were discussed, but the value of a marsh was measured in monetary terms

(Continued)

* Does the document provide methodologies or procedures?
** Does the methodology address wetland functional values?
† Does the methodology evaluate wetland functions by methods other than monetary values?

(Sheet 1 of 5)

Table 9 (Continued)

Methodology Number	Citation	Methodology	Wetland Functions	Nonmonetary Assessment	Decision Rationale
e	California Coastal Commission. 1979	No	Yes	Yes	Document provides guidelines for reviewing permit applications in coastal areas of California. The purpose of the document was not to evaluate wetland functions
f	Commonwealth of Virginia. 1974	No	Yes	Yes	Document provides guidelines for reviewing permit applications in Virginia. The objective of the document was not to evaluate wetland functions
g	Coordinating Council on the Restorations of the Kissimmee River Valley and the Creek-Nubbin Slough Basin. 1978	No	Yes	No	Document does not provide a methodology for evaluating wetland functions. The objective of the document was to review efforts in the watershed of this area
h	Foster, J. H. 1978	No	No	No	Document does not provide a methodology. Wetland functions are not specifically addressed. The objective of the paper was to suggest monetary values for wetlands

(Continued)

(Sheet 2 of 5)

Table 9 (Continued)

Methodology Number	Citation	Methodology	Wetland Functions	Nonmonetary Assessment	Decision Rationale
i	Fritz, W. R. 1978	No	Yes	Yes	Document does not provide a methodology for evaluating a wetland for functional values. The objective of the document was to assess cypress wetlands for wastewater treatment
j	Gosselink, J. G., et al. 1974	Yes	Yes	No	Value of a tidal marsh ecosystem is translated into monetary values. The purpose of the document was to illustrate economic values of wetlands
k	Gupta, T. R. 1972	No	Yes	No	Document does not provide procedures for evaluating wetland function; monetary values are implied
l	Hill, D. 1976	Yes	Yes	No	The methodology evaluates wetlands only in monetary terms
m	Larson, J. S. 1973	No	Yes	Yes	Document provides a good discussion of wetland functional values, but it does not contain a procedure for evaluating wetlands

(Continued)

(Sheet 3 of 5)

Table 9 (Continued)

Methodology Number	Citation	Methodology	Wetland Functions	Nonmonetary Assessment	Decision Rationale
n	New York State Department of Environmental Conservation. Undated	No	Yes	Yes	Document does not provide a procedure for evaluating wetland functions. The objective of the report was to interpret New York State statutes concerning wetlands
o	Shabman, L. A., et al. 1979	Yes	Yes	No	Procedure is based upon monetary values of wetlands
p	Silberhorn, G. M., et al. 1974	No	Yes	Yes	Document does not contain a procedure for evaluating wetlands. Wetland functions were discussed briefly; monetary values of wetlands were not stated
q	U. S. Department of Agriculture. 1974	No	Yes	Yes	The purpose of the document was not to provide a procedure for evaluating wetlands. Soil Conservation Service policies, procedures, and guidelines for preparing Environmental Impact Statements were discussed
r	U. S. Environmental Protection Agency. 1976	Yes	No	Yes	Document does not address wetland functions
s	Wharton, W. H. 1970	Yes	Yes	No	Procedures are associated with monetary values for functions

(Continued)

(Sheet 4 of 5)

Table 9 (Concluded)

Methodology Number	Citation	Methodology	Wetland Functions	Nonmonetary Assessment	Decision Rationale
t	Whitaker, G. A., and McCuen, R. H. 1975	Yes	No	Yes	Methodology does not address wetland functional values
u	Williams and Works. 1979	No	Yes	Yes	Document does not provide a procedure for evaluating wetland functions. The objective was to examine artificial wetlands for wastewater treatment

(Sheet 5 of 5)

APPENDIX A: DOCUMENTS REVIEWED AND AVAILABILITY AND TIME REQUIREMENTS OF METHODOLOGIES THAT SATISFIED EVALUATION CRITERIA

DOCUMENTS REVIEWED

Bara, M. O., Tiner, R. W., Jr., and Newkrik, D. C. 1977. "Guidelines for Evaluating Proposed Wetland Alterations in South Carolina," S. C.

Battelle-Pacific Northwest Laboratories. 1974. "A Technique for Environmental Decision Making Using Quantified Social and Aesthetic Values," Publication No. BNWL-1787, Richland, Wash.

Belknap, R. K., and Furtado, J. G. 1967. "Three Approaches to Environmental Resource Analysis," The Conservation Foundation, Washington, D. C.

Benson, D., and Perry, R. F. 1965. "An Acre of Marsh in Worth," The Conservationist, pp 30-33.

Brown, A., Kittle, P., Dale E. E., and Huffman, R. T. 1974. "Rare and Endangered Species, Unique Ecosystems and Wetlands," Department of Zoology and Department of Botany and Bacteriology, University of Arkansas, Fayetteville, Ark.

California Coastal Commission. 1979. "Statewide Interpretive Guidelines for Wetlands and Other Environmentally Sensitive Habitat Areas (Draft)," San Francisco, Calif.

Commonwealth of Virginia. 1974. "Wetlands Guidelines," Marine Resources Commission, Newport News, Va.

Coordinating Council on the Restoration of the Kissimmee River Valley and Taylor Creek-Nubbin Slough Basin. 1978. "Environmental Quality Through Wetlands Utilization," Proceedings of a Symposium on Freshwater Wetlands, Tallahassee, Fla.

Dee, N., et al. 1973. "Environmental Evaluation System for Water Resources Planning," Water Resources Research, Vol 9, No. 3, pp 523-534.

Foster, J. H. 1978. "Measuring the Social Value of Wetland Benefits," The National Symposium on Wetlands, Lake Vista, Florida, University of Massachusetts, Amherst, Mass.

Fried, E. 1974. "Priority Rating of Wetlands for Acquisition," Transactions of the Northeast Fish and Wildlife Conference, Vol 31, pp 15-30.

Fritz, W. R. 1978. "Tertiary Treatment of Wastewater Using Cypress Wetlands; Summary and Final Report," Boyle Engineering Corporation, Orlando, Fla.

Galloway, G. E. 1978. "Assessing Man's Impact on Wetlands," Sea Grant Publication No. UNC-SG-78-17 or UNC-WRRI-78-136, University of North Carolina, Raleigh, N. C.

Golet, F. C. 1973. "Classification and Evaluation of Freshwater Wetlands as Wildlife Habitat in the Glaciated Northeast, Transactions of the Northeast Fish and Wildlife Conference, Vol 30, pp 257-279.

Gosselink, J. G., Odum, E. P., and Pope, R. M. 1974. "The Value of the Tidal Marsh," Publication No. LSU-SG-74-03, Center for Wetland Resources, Louisiana State University, Baton Rouge, La.

Gupta, T. R. 1972. "Economic Criteria for Decisions on Preservation and Use of Inland Wetlands in Massachusetts," Journal of the Northeastern Agricultural Economics Council, Vol 1, No. 1, pp 201-210.

Gupta, T. R., and Foster, J. H. 1973. "Valuation of Visual-Cultural Benefits from Freshwater Wetlands in Massachusetts," Journal of the Northeastern Agricultural Council, Vol 2, No. 2, pp 262-273.

Hill, D. 1976. "A Modeling Approach to Evaluate Tidal Wetlands," Transactions of the Wildlife Management Institute's Forty-First North American Wildlife and Natural Resources Conference, Washington, D. C.

Kibby, H. V. 1978. "Effects of Wetlands on Water Quality," Proceedings of the Symposium on Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems, General Technical Report No. CTR-WO-12, U. S. Department of Agriculture, Forest Service, Washington, D. C.

Larson, J. S. 1973. "A Guide to Important Characteristics and Values of Fresh Water Wetlands in the Northeast," No. 31, University of Massachusetts, Amherst, Mass.

Larson, J. S. ed. 1976. "Models for Assessment of Freshwater Wetlands," Pub. No. 32, Water Resources Research Center, University of Massachusetts, Amherst, Mass.

New York State Department of Environmental Conservation. Undated. "Freshwater Wetland Maps and Classification (Draft)."

Reppert, R. T., et al. 1979. "Wetland Values: Concepts and Methods for Wetlands Evaluation," IWR Research Report 79-R-1, U. S. Army Engineer Institute for Water Resources, Fort Belvoir, Va.

Schuldiner, P. W., Cope, D. F., and Newton, R. B. 1979a. "Ecological Effects of Highway Fills on Wetlands Research Report," National Cooperative Highway Research Program Report No. 218A, Transportation Research Board, National Research Council, Washington, D. C.

Schuldiner, P. W., Cope, D. F., and Newton, R. B. 1979b. "Ecological Effects of Highway Fills on Wetlands Users Manual," National Cooperative Highway Research Program Report No. 218B, Transportation Research Board, National Research Council, Washington, D. C.

Stearns, Conrad, and Schmidt - Consulting Engineers. 1979. "Analysis of Selected Functional Characteristics of Wetlands," Contract No. DACW 73-78-R-007, Reston, Va.

Shabman, L. A., Batie, S. S., and Mabbs-Zeno, C. C. 1979. "The Economics of Wetlands Preservation in Virginia," Research Report No. A. E. 38, Virginia Polytechnic Institute and State University, Blacksburg, Va.

Silberhorn, G. M., Dawes, G. M., and Barnard, T. A., Jr. 1974. "Coastal Wetlands of Virginia/Guidelines for Activities Affecting Virginia Wetlands," Interim Report No. 3, Virginia Institute of Marine Science, Gloucester Point, Va.

Smardon, R. C. 1972. Assessing Visual-Cultural Values on Inland Wetlands in Massachusetts, Master of Science Thesis, University of Massachusetts, Amherst, Mass.

Solomon, R. C., et al. 1977. "Water Resources Assessment Methodology (WRAM)--Impact Assessment and Alternative Evaluation," Technical Report Y-77-1, Environmental Effects Laboratory, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

State of Maryland Department of Natural Resources. Undated. "Environmental Evaluation of Coastal Wetlands (Draft)," Tidal Wetlands Study, pp 181-208.

U. S. Army Engineer Division, Lower Mississippi Valley. 1980. "A Habitat Evaluation System (HES) for Water Resources Planning," Vicksburg, Miss.

U. S. Army Engineer Division, New England. 1972. "Charles River; Main Report and Attachments," Waltham, Mass.

U. S. Department of Agriculture. 1974. "Environmental Assessment Procedure," Soil Conservation Service, Washington, D. C.

U. S. Department of Agriculture. 1978. "Wetlands Evaluation Criteria--Water and Related Land Resources of the Coastal Region, Massachusetts," Soil Conservation Service, Washington, D. C.

U. S. Environmental Protection Agency. 1976. "Environmental Assessment Perspectives," EPA-600/2-76-069, Industrial Environmental Research Laboratory, Office of Research and Development, Research Triangle Park, N. C.

U. S. Fish and Wildlife Service. 1980. "Habitat Evaluation Procedures (HEP) Manual," 102 ESM, Washington, D. C.

Virginia Institute of Marine Science. Undated. "Evaluation of Virginia Wetlands" (Mimeographed).

Wharton, C. H. 1970. "The Southern River Swamp--A Multiple Use Environment," Bureau of Business and Economic Research, Georgia State University.

Whitaker, G. A., and McCuen, R. H. 1975. "A Proposed Methodology for Assessing the Quality of Wildlife Habitat," Department of Civil Engineering, University of Maryland, College Park, Md.

Williams and Works. 1979. "Reuse of Municipal Wastewater by Volunteer Wetlands--Interim Report, 1979," Grand Rapids, Mich.

Winchester, B. H., and Harris, L. D. 1979. "An Approach to Valuation of Florida Freshwater Wetlands," Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands, Tampa, Fla.

Table A1

Availability and Time Requirements of Methodologies that Satisfied Evaluation Criteria

Methodology Number	Citation	Availability of Methodology	Time Requirements Necessary to Implement the Procedure
1	Brown, A., et al. 1974	Arkansas Department of Local Services State of Arkansas Little Rock, Arkansas	Approximate time requirements were not discussed
2	Dee, N., et al. 1973	Water Resources Research Volume 9. pp 523-534. 1973	Extensive time requirements
3	Fried, E. 1974	No response	No response
4	Galloway, G. E. 1978	NTIS: The DDC/DTC accession number is ADA 094652	Time requirements are rather extensive
5	Golet, F. C. 1973	Dr. F. C. Golet Department of Forest and Wildlife Management Woodward Hall University of Rhode Island Kingston, R. I. 02881	"The number of man-hours required to implement the rating procedure depends upon the size and vegetative diversity of each wetland, the number of wetlands being evaluated and the experience of the user. Assuming. (1) that the user is able to identify wetland classes and some subclasses reasonably well using a lens stereoscope and aerial photographs; (2) that topographic maps, surficial geology maps and a portable pH meter are readily available; and (3) that a vehicle and, perhaps, a canoe are available for field work, a moderate-sized wetland (50 to 100 acres) with a moderate diversity of vegetation types can be evaluated in 4-8 man-hours. One should realize that, once photo-interpretation skills are well developed, a small wetland may be evaluated in a matter of minutes, except for the pH measurement which requires field sampling. During a wetlands inventory, if several wetlands are classified and field-checked at the same time, it is possible to evaluate 10 or more wetlands in one man-day. In a recent survey of wetlands in Richmond, Rhode Island, my research assistant mapped, classified, evaluated and field-checked 607 wetlands in 15 weeks (600 man-hours). Wetland size ranged from 0.05 ha to 142.3 ha; the average size was 1.4 ha. Included in the 600 hours was time required to measure the area of each wetland subclass with a planimeter and to record area statistics." (F. C. Golet)
6	Gupta, T. R. and Foster, J. H. 1973	Journal of the Northwestern Agricultural Council. Volume 2. pp 262-273. 1973	"I would judge that one experienced with the evaluation procedure and with desired maps in hand could do up to four field evaluations per day, depending on travel time between wetlands." (J. H. Foster)
7	Kibby, H. V. 1978	General Technical Report No. CTR-WO-12. U.S.D.A., Forest Service, Washington, D. C.	No estimate given

(Continued)

Sheet 1 of 4

Table A1 (Continued)

Methodology Number	Citation	Availability of Methodology	Time Requirements Necessary to Implement the Procedure
8	Larson, J. S., ed. 1976	Water Resource Research Center Publ. No. 32 University of Massachusetts Amherst, Mass. 01003 Cost: $3.00	"If all the map and aerial photography materials are available a 100 acre wetland can be done by one person in one day, assuming 1/2 day field inspection to check map and photo accuracy and current conditions, plus 1/2 day of office calculations. Several smaller wetlands can be done in less time. Very large wetlands may be done in less than the rate of 100 acres/day if field inspection by aerial reconnaissance is available." (J. S. Larson)
9	Reppert, R. T., et al. 1979	National Technical Information Service (#ADA069088) U. S. Department of Commerce Springfield, Virginia 22151	"Approximately eight hours is required to implement each of the two procedures (i.e., deductive and comparative analysis)." (R. T. Reppert)
10	Schuldiner, P. W., et al. 1979	Transportation Research Board 2101 Constitution Ave., N. W. Washington, D. C. 20418	No estimate available
11	SCS Engineers. 1979	Stearns, Conrad and Schmidt Consulting Engineers, Inc. 11260 Roger Bacon Drive Reston, Virginia 22090 or U. S. Army Coastal Engineering Research Center Kingman Bldg. Telegraph and Leaf Roads Fort Belvoir, VA 22060	No estimate available
12	Smardon, R. C. 1972	"The entire thesis can be obtained from NTIS and the Department of Landscape Architecture and Regional Planning, Hills North, University of Massachusetts, Amherst 01003 at the cost of zeroxing.	"This depends on the size of the wetland(s) in question and the availability of appropriate data. The amount of time can range from that needed to evaluate a small wetland (one-hour) to that needed to evaluate a large wetland system (one to two person days). A medium amount would average 4 to 5 person hours, at the most." (R. C. Smardon)

(Continued)

Table A1 (Continued)

Methodology Number	Citation	Availability of Methodology	Time Requirements Necessary to Implement the Procedure
12	Smardon, R. C. 1972 (Cont'd)	If these institutions were not able or willing to make copies available, I could make copies available at cost through the School of Landscape Architecture, College of Environmental Science and Forestry, S.U.N.Y., Syracuse, N. Y. 13210."	
13	Solomon, R. C., et al. 1977	National Technical Information Service U. S. Department of Commerce Springfield, Virginia 22151	"Time requirements are dependent on the stage of planning/complexity of the problem. If small groups of individuals are discussing "gross" impacts of a few alternatives on a few variable, the actual calculations can be completed in a few minutes. If the procedure is being used for extensive evaluations of many alternatives for a multiobjective study, it could require several hours to complete calculations." (W. J. Hansen)
14	State of Maryland, Department of National Resources. Undated	No response	No response
15	U. S. Army Engineer Division, Lower Mississippi Valley (HES). 1980	U. S. Army Engineer Division Lower Mississippi Valley Environmental Branch Attention: LMVPD-R P. O. Box 80 Vicksburg, Mississippi 39180	"After the completion of personnel training, 20-50 plots can be sampled in a day depending upon distance between plots. Office time requirements vary from one to three days and are dependent upon project complexity." (H. Moore)
16	U. S. Army Engineer Division, New England. 1972	"The feasibility study is no longer available. However tabloids describing the study and two appendices, i.e. Hydrology and Hydraulics and Flood Management Plan Formulation are available from:	"No estimate (man-hour) can be made of time required to implement a procedure for wetland acquisition." (A. F. Doyle)

(Continued)

Table A1 (Concluded)

Methodology Number	Citation	Availability of Methodology	Time Requirements Necessary to Implement the Procedure
16	U. S. Army Engineer Division, New England, 1972 (Cont'd)	Arthur F. Doyle, NED Department of the Army New England Division, Corps of Engineers 424 Trapelo Road Waltham, Massachusetts 02254	
17	U. S. Department of Agriculture. 1978	U. S. Department of Agriculture Soil Conservation Service 451 West Street Amherst, Massachusetts 01002	"Approximately one day of training (one-half day classroom and one-half day field) in using the procedures was provided to our resource planning personnel personnel that would be doing the field evaluations. Our personnel required an average of three hours to conduct one wetland field evaluation. Personnel were all professional natural resource planners with previous experience in wetland typing." (S. L. Lewis)
18	U. S. Fish and Wildlife (HEP). 1980	Mel Shamberger, HEP Group Leader Office of Biological Services Fish and Wildlife Service Drake Creekside Bldg. 2625 Redwing Road Fort Collins, Colorado 80526 (Available from NTIS by end of FY 1981)	"The amount of time necessary to implement the procedure is dependent on the size of the area, the number of cover types, the number of evaluation species, and the number and types of proposed impacts. The HEP may be completed in several days or the procedure may require several months of field investigations and data analysis." (D. Peterson)
19	Virginia Institute of Marine Science. Undated	No response	No response
20	Winchester, B. H. and Harris, L. D. 1979	Brian Winchester 7201 N. W. 11th Place P. O. Box 1647 Gainesville, Florida 32602 ("A copy should be available from Hillsborough Community College after their 1981 Wetlands Conference) (B. Winchester)."	"A 20 acre wetland, with good aerial photo available, a ranking could be obtained within 2 hours (includes desk-top work but does not include travel time to the site)." (B. Winchester)

Sheet 4 of 4

APPENDIX B: GLOSSARY

acquisition--The act of purchasing wetlands from private sources, usually for preservation; may be based on a per-acre desirability for purchase.

decisionmaker--Resource manager.

end product--The evaluation summary of a wetland evaluation procedure; the end product may be a numerical value, narrative report, matrix, graph, etc.

flexibility--Responsiveness; an evaluation feature that allows for quick answers from limited data and detailed answers with additional data.

hydrology--The science dealing with water, its properties, phenomena, and distribution especially with reference to water on the surface of the land, in the soil, and underlying rocks.

juxtaposition--The state of being placed side by side. An impact that occurs in an adjacent area outside a wetland, but affects the functioning of the wetland.

management--The act of managing the natural resource of a wetland.

methodology--A system of principles, practices, and procedures applied to assess the relative quality or relative value of a wetland. For the purposes of this report the term is synonymous with a procedure.

mitigation--An action that is employed to moderate the force or intensity of an impact or to alleviate the effects of an impact in a wetland. The President's Council on Evironmental Quality defined the term "mitigation" in the National Environmental Policy Act regulations as a planning process. That process includes "(1) avoiding the impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (5) compensating for the impact by replacing or providing substitute resources or environments."

procedure--A set of methods for assessing the relative quality or relative value of a wetland. For the purposes of this report the term is synonymous with a methodology.

red flag--A feature of a procedure that emphasizes a key, sensitive wetland function, i.e., a habitat for a rare and endangered species, or a site containing significant archaeological information.

resource manager--An individual who has sufficient technical or scientific skills to perform a wetland evaluation; an individual who has been trained in a scientific discipline related to wetland functional values.

responsiveness--Flexibility; see definition of "flexibility" above.

value judgment--A response derived from field experiences and insights into the functions and values of wetland ecosystems.

wetland functions--For the purposes of this report, a wetland may provide the following values that can be used in the analysis of wetland evaluation procedures:

Major Categories	Related Subcategories
Habitat	Common wetland plant and animal species Endangered, threatened, or rare plant and animal species Game species: aquatic terrestrial avian Commercial species Nongame species
Hydrologic	Floodwater conveyance and storage Wave energy dissipation and shoreline protecton Ground and surface water supply including recharge and discharge Water quality including waste assimilation and sediment trapping
Recreation	Water-oriented activities such as canoeing. Other activities such as photography, bird watching, and camping
Agriculture/ Siliviculture	Cultivated crops Pastureland and hay crops Forestry Peat
Heritage	Landscape: natural and unique areas open space Cultural: archaeological sites historical sites Scientific: research education

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